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APPLIED MECHANICS REVIEWS

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SHIP VIBRATION

Part II: Vibrational Characteristics of Ship Hulls

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The problem of predicting the performance of a proposed ship with respect to vibration involves the two phases of estimating the forces which will act on the hull and estimating the response of the hull to given forces. This article is concerned with the latter problem and particularly with the response to steady-state propeller exciting forces as contrasted with the response to transient forces due to slamming under rough sea conditions. This is a companion to the feature article by Professor J. P. Breslin, appearing in the July 1960 issue of AMR, on the propeller exciting effects themselves. The two articles in combination are intended to present a picture of the present status of the problem of propeller-excited hull vibration. The first half of the present article is essentially an historical introduction. The material presented in the second half is derived from a recent article in *Journal of Ship Research* (1).

The principal modes of vibration of a hull correspond in general to those of a free-free beam, that is, a beam without restraints at either end. The consideration of the modes of vibration of uniform bars, both solid and hollow, and under various types of end restraint comprises an important branch of acoustics and has been extensively treated in the technical literature (2). While solid uniform bars are subject to analysis by classical methods, at least to a limited extent, it is not possible to transfer these methods directly to so complex a system as the hull of a ship. Nevertheless, in considering the most significant mode of hull vibration, namely the fundamental vertical mode, the comparison with the vibration of the free-free uniform bar has proven quite fruitful.

The vibrating hull departs from the vibrating free-free solid bar not only in its structural complexity but in the fact that it is partially submerged in a relatively dense fluid which exerts a marked influence on its vibrational characteristics. Although the water exerts elastic, inertia, and damping effects on a vibrating hull, the inertia effect is the most significant in the range of vibration frequencies under consideration here. Hence in vibration analysis the hull is usually treated as a beam free in space with a distributed mass added to allow for the effect of the surrounding water. In this idealization of the actual system it is to be noted that the rigid body motions have infinite periods since there are no restraints whatever, whereas the ship has finite periods in roll, pitch, and heave due to the buoyancy of the water.

In spite of the fact that hull vibration research has been in progress since, roughly, the beginning of the century, the mathematical treatment of the system in question as regards both its elastic properties and its inertial properties (including the effect of the surrounding water (3), (4)) cannot as yet be considered satisfactory.

Among the first pioneers in ship vibration research was O. Schlick (5) who proposed the celebrated empirical formula for the fundamental vertical mode of vibration of surface ships:

$$N = C \sqrt{\frac{I}{DL^3}}$$

where (in practical English units)

- N is the frequency in cpm
- C is Schlick's empirical "constant" with a range of values from 1.28×10^8 to 1.57×10^8 according to the type of ship
- I is the moment of inertia of the area of the midship section with respect to the neutral axis in ft^2 in^2 units
- D is the displacement in long tons (2240 pounds)
- L is the length of the hull in feet

This formula is based on the corresponding formula for the free-free uniform bar derived from the classical treatment (2).

Among other early investigators in the ship vibration field was A. N. Krylov whose work dates from the beginning of the century. His book on the subject (6) is devoted chiefly to the fundamentals of mechanical vibration and the application of classical beam theory to the hull vibration problem. The work of numerous other pioneers in this field is indicated in the list of additional references.

For many years the chief interest in the subject centered around the prediction of the fundamental vertical frequency of the hull and its accompanying mode shape. There was a practical reason for this since this mode was frequently excited by propeller or shafting unbalance (7) under the manufacturing tolerances existing at the time. Numerous attempts were made to modify the classical beam theory to allow for the nonuniformity in the distribution along the length of the hull of weight, bending rigidity, shearing rigidity, and water inertia effect. The

application of the Stodola method to this problem, involving graphical integration, was discussed in considerable detail by E. Schadlofsky (8) in 1932.

At about this same time impetus to the experimental phase of the subject was furnished by the manufacture of machines capable of vibrating entire hulls. This took place in Germany where such machines had been previously designed by the firm of Losenhausen in Dusseldorf for the dynamic testing of riveted and welded bridges. These machines contained adjustable eccentric masses so arranged that unidirectional sinusoidal forces and couples could be produced (9).

The largest machine of this type when built was delivered to the U. S. Experimental Model Basin by Losenhausen in 1931. From that date until the present time the U. S. Experimental Model Basin and its successor, the David Taylor Model Basin, maintained and developed machines of this general type (10), and conducted experiments to verify theoretical predictions of hull vibration characteristics.

Simultaneously and especially since the end of World War II, ship vibration research has been carried on at an expanding rate by the principal maritime nations of the world, as is evident from the references at the end of this article.

In the United States the Society of Naval Architects and Marine Engineers has done much to stimulate interest in ship vibration research and has cooperated closely with the Bureau of Ships of the Navy Department in this field. At present this society maintains two research panels concerned especially with the ship vibration problem.

In considering recent developments it must first be noted that the graphical methods of hull vibration analysis (such as discussed in (8)) were found to have severe limitations in the higher modes. It was not until the production of digital and analog computers on a grand scale that substantial progress in the direction of calculating higher modes was achieved.

As shown in (11) and (12), from the strictly mathematical point of view, it has been found possible in recent years to calculate flexural, torsional, and torsion-bending normal modes and natural frequencies of hulls as well as their steady-state forced response. Recent investigations indicate the desirability of considering the hull as a free-free beam with three principal types of flexibility, namely bending, shearing, and twisting. However, the limitations of this concept must be clearly recognized. The fundamental vertical and horizontal modes are predominantly bending modes whose frequency is lowered by a few per cent due to shearing flexibility. In the higher modes the importance of shearing increases relative to bending so that by the time the sixth mode is reached the deformation is predominantly in shearing. The vertical flexural modes may usually be considered free of torsion due to symmetry with respect to the vertical plane through the longitudinal axis of the ship. On the other hand, the horizontal modes are usually not free of torsion due to the lack of symmetry. However, few calculations have so far been made of the torsion-bending modes and the usual practice has been to consider vertical, horizontal, and torsional vibrations as independent of one another.

Experiments have shown that ship hull modes depart from the modes of vibration predicted by beam theory (even the so-called Timoshenko beam theory which includes the shearing effect) to an increasing degree as the frequency is raised. The errors in prediction are due not only to uncertainty in the evaluation of the beam parameters themselves but to local flexibility of the supporting structures which permits large masses installed in the hull to move relative to the hull girder itself. The latter effect obviously applies also to units installed in the ship on resilient mountings and is spoken of colloquially as the "sprung mass" effect (13).

Forced vibration of hulls can be calculated on the basis of beam theory either by the finite difference method or by the normal mode method. Here damping must be taken into account and where equivalent viscous damping is used the digital process can be carried out by the use of rotating time vectors and complex notation as in alternating current theory (11).

As shown in (14), by estimating equivalent Rayleigh damping the response of a hull to a simple harmonic driving force may be computed by the normal mode method which yields the response in terms of an infinite series. It has been found useful in practice to apply this method while limiting the summation to the first few normal mode components.

On account of the unsatisfactory state of the beam theory of hull vibration it has been suggested in recent years (15) to abandon this theory altogether and substitute therefore a three-dimensional analysis of the hull. While work along this line is in progress no information on the success of this scheme is available to the author at this writing.

As to specific information which should be useful to the naval architect in avoiding trouble from propeller-excited hull vibration, the following is a modified version of that part of reference (1) which deals with the vibrational response characteristics of the hull.

Without resort to the detailed calculation of the normal modes and natural frequencies of the hull the fundamental vertical frequency can be estimated by one of the empirical formulas proposed by Schlick (5), Prohaska (16), or Todd and Marwood (17). In practice it has been found that the frequencies of the vertical modes conform fairly closely to the series 1, 2, 3, etc. This is clearly not due to similarity to the ideal free-free uniform slender bar whose higher modes are not harmonics of the fundamental but follow the series 3^2, 5^2, 7^2, 9^2, etc.

The frequency of the fundamental horizontal mode can be estimated from that of the fundamental vertical mode by an empirical formula given by A. J. Johnson (18) and again the 1, 2, 3, rule can be used for estimating the frequencies of the higher horizontal modes.

A formula for the fundamental torsional mode was proposed by F. Horn (19). This is discussed in reference (14). The available data on torsional modes of hulls are insufficient to establish reliable ratios of the frequencies of the higher modes to that of the fundamental mode at this time. For SS GOPHER MARINER (11) the frequencies of the first three torsional modes (considered as flexure-free) fell in the ratios 1 : 1.6 : 2.2.

Experience has shown that the number of beamlike hull modes that are significant is quite limited. While "sigificance" here is somewhat arbitrary this statement means that when the frequency of the driving force acting on the hull exceeds a limited value the response patterns are not well defined and cannot be identified as corresponding to any of the modes of the ideal free-free beam. Unless the ratio of length to depth of the hull exceeds 18 there will be found only about six significant vertical modes, four horizontal modes and three torsional modes. When the torsional and horizontal flexural modes are considered as coupled torsion-bending modes this rule gives seven significant modes of that type. L. A. Baier and J. Ormondroyd (20) suggested a formula for the number of significant vertical modes in terms of length, beam, and depth, namely

$$N \approx \frac{5}{9}\frac{L}{D} \approx \frac{L}{B}$$

where N = number of significant modes
L = hull length
D = hull depth
B = hull beam

In predicting the amplitude of hull vibration that will result from the application of a given driving force at the stern both analog and digital methods are in use. The digital method is

discussed in reference (21) and the application is further discussed in (11). The analog method of calculating forced vibration of beams is discussed in reference (22). In addition to the digital process, present methods of estimating forced vibration of hulls include the normal mode method and the mechanical impedance method, both of which are discussed in reference (11). The criteria on which the selection of a suitable method must be based include the magnitude of the driving frequency, the available computing facilities, and the extent of the available data on the inertia and elastic parameters of the particular hull in question. All such attempts must be regarded as semi-empirical, especially when the driving frequency is above the the range of frequencies of significant hull modes.

The normal mode method has the advantage that the series summation can be limited to the components in the significant hull modes. The mechanical impedance concept is particularly useful in estimating amplitudes in the range of frequencies above that of the significant normal modes.

In reference (11) the following empirical formula for the vertical vibration at the stern of ships (based on the impedance concept) was proposed:

$$Y = \frac{P_0}{3.4 \times 10^{-6} \times D \times (\text{cpm})^2}$$

where Y = single amplitude in mils
P_0 = amplitude of driving force in pounds
D = displacement of the ship in long tons
cpm = the driving frequency in cycles per minute

This formula was recommended for blade frequencies above the range of significant vertical mode frequencies.

When the driving frequency falls in the range of significant hull mode frequencies it is usually most desirable to estimate the amplitude that will be produced under a resonant condition in which the frequency coincides with one of the natural frequencies. In this case the response in the resonant mode is so much greater than the response in any of the other modes that the latter is usually neglected.

The mode in question, whose frequency and pattern are assumed to have been computed previously by analog, digital, or graphical methods, may then be treated as though the system had only one degree of freedom. When the effective values of inertia, elasticity, and damping have been evaluated for the mode in question and with respect to the given driving point a mechanical impedance may then be derived from these values. At the resonant frequency the inertia and elastic components cancel one another and only the damping component of this impedance remains.

As indicated in reference (1) experience has shown that in the case of hulls a viscous damping coefficient varying with frequency is more realistic than Rayleigh damping. An average experimental damping value is

$$c \approx 0.03 \mu\omega$$

where c is the viscous damping coefficient (force per unit length per unit velocity)
μ is the mass per unit length (including the allowance for added mass of water)
ω is the circular frequency

This magnitude of damping corresponds to about 1 1/2 per cent of critical damping. When the mass of the hull is generalized to an effective mass at the driving point for the resonant mode in question (say the ith mode), the equation for the amplitude at the driving point is

$$y_{di} = \frac{P_0}{C_{di}\omega_i}$$

where P_0 is the amplitude of the driving force and
C_{di} is the effective viscous damping constant of the entire hull at the driving point for the ith mode.

From the above recommended value for c

$$C_{di} \approx 0.03\, M_{di}\omega_i$$

where M_{di} is the effective mass of the entire hull at the driving point for the ith mode.

From the normal mode theory (14)

$$M_{di} = \frac{\int_0^L \mu Y_i^2(x)\,dx}{Y_{di}^2}$$

where $Y_i(x)$ is the normal mode displacement pattern for the ith normal mode and
Y_{di} is the value of the normal mode pattern at the driving point.

Thus, if the mass distribution and normal mode shape are available, an estimate of the resonant amplitude at the point at which a known simple harmonic driving force is applied can be made for a torsion-free flexural mode. The extension of this scheme to torsion and torsion-bending modes is discussed in reference (1).

REFERENCES

1 Tachmindji, A. J., and McGoldrick, R. T.: "Note on propeller-excited hull vibration," *Journal of Ship Research* **3**, no. 1, June 1959; AMR **13**(1960), Rev. 2102.

2 Rayleigh, Lord: "Theory of sound," Dover Publications, New York, 1945.

3 Lewis, F. M.: "The inertia of water surrounding a vibrating ship," *Trans. SNAME* **37**, 1929.

4 Landweber, L., and de Macagno, M. C.: "Added mass of two-dimension forms oscillating in a free surface," *Journal of Ship Research*, Nov. 1957.

5 Schlick, O.: Series of articles on ship vibration in *TINA* 1884, 1893, 1894, 1901, 1911.

6 Krylov, A. N.: "Vibration of ships" (book published in Russian, 1936).

7 Lewis, F. M.: "Dynamic effects," Chapter 2, Vol. 2, *"Marine Engineering,"* edited by H. L. Seward, published by SNAME, 1944.

8 Schadlofsky, E.: "Uber Rechnung und Messung der elastischen Eigenschwingungen von Schiffskorpern," S.T.G., Vol. 33, 1932; EMB Translation no. 7, June 1934.

9 Spath, W.: "Theory and practice of vibration testing machines;" EMB Translation no. 51, Mar. 1938.

10 Robinson, Q. R.: "Vibration machines at the David Taylor Model Basin," TMB Rep. 821, July 1952.

11 McGoldrick, R. T., and Russo, V. L.: "Hull vibration investigation on SS GOPHER MARINER," *Trans. SNAME* **63**, 1955; also issued as TMB Rep. 1060, July 1956; AMR **10**(1957), Rev. 2736.

12 McGoldrick, R. T.: "Comparison between theoretically and experimentally determined natural frequencies and modes of vibration of ships," TMB Rep. 906, Aug. 1954.

13 Kennard, E. H.: "Forced vibration of beams and the effect of sprung masses," TMB Rep. 955, July 1955.

14 McGoldrick, R. T., Gleyzal, A. N., Hess, R. L., and Hess, G. K., Jr.: "Recent developments in the theory of ship vibration," TMB Rep. 739, Feb. 1951.

15 Schade, Commodore H. A., USN(Ret): discussion of the paper included in Reference (11).

16 Prohaska, C. W.: "The vertical vibration of ships," *The Shipbuilder and Marine Engine Builder*, October and November 1947.

17 Todd, F. H., and Marwood, W. J.: "Ship Vibration," N.E.C.I. Transactions, **64**, 1948.

18 Johnson, A. J.: "Vibration tests on all-welded and all-riveted 10,000 ton dry cargo ships," N.E.C.I. Transactions, 1951.

19 Horn, F.: "Horizontal and torsions-Schiffschwingungen auf Frachtschiffen," WRH, September 1925.

20 Baier, L. A., and Ormondroyd, J.: "Vibration at the stem of single screw vessels," *Trans. SNAME* **60**, 1952.

21 Adams, E. J.: "The steady-state response of a ship hull to a simple harmonic driving force computed by a digital process," TMB Rep. 715, 1950.

22 McCann, G. D., and MacNeal, R. H.: "Beam-vibration analysis with the electric analog computer," paper presented at semi-annual meeting of ASME, 1949.

ADDITIONAL REFERENCES

Babaev, N. N., "Contemporary status of development of the problem of ship vibration," TMB Translation no. 291, July 1959.

Bunyan, T. W., "Practical approach to some vibration and machinery problems in ships," Paper presented to the Institute of Marine Engineers and the Institution of Naval Architects, February 1955.

Cole, A. P., "The natural periods of vibrations of ships," *Institute of Engineers and Shipbuilders-Scotland, Trans.* **72**, 1928-29.

Csupor, D., "Methoden zur Berechnung der Freien Schwingungen des Schiffskorpers," STG Vol. 50, 1956 (available as TMB Translation T288), May 1959.

Dieudonne, J., "Vibration in ships," translation by W. C. S. Wigley, T.I.N.A., 1958.

Fothergill, A. E., "Vibrations in marine engineering," *Institution of Engineers and Shipbuilders in Scotland, Trans.* **95**, 1951-52, Part 4.

Gumbel, L., "Torsional vibrations of elastic shafts of any cross section and mass distribution and their application to the vibration of ships," T.I.N.A., **LIV**, 1912.

Hardy, V. S., "Vibration studies of ship hulls by means of vibration generators," DTMB Rep. C-80, Nov. 1949.

Horn, F., "Horizontal und torsions-Schiffschwingungen auf Frachtschiffen," WRH Vol. 6, 1925, Heft 18.

Inglis, C. E., "Suggested method of minimizing vibration in ships," T.I.N.A., 1933.

Jasper, N. H., "Structural vibration problems of ships—A study of the DD 692 class of destroyers," TMB Rep. C-36, Feb. 1950.

Johnson, A. J., and Ayling, P. W., "Graphical presentation of hull frequency data and the influence of deck-houses on frequency prediction," N.E.C.I., **13**, part 7, May-June 1957; AMR **11**(1958), Rev. 2992.

Koch, J. J., "Eine Experimentelle Methode zur Bestimmung der Reduzierten Masse des Mitschwingenden Wassers bei Schiffschwingungen," *Ing.-Arch.* **IV**, no. 2, 1933.

Kumai, T., "Coupled torsional-horizontal bending vibrations in ships," *European Shipbuilding* no. 4, 1956.

Kumai, T., "Damping factors in the higher modes of ship vibrations," *European Shipbuilding* no. 1, 1958; AMR **12**(1959), Rev. 1208.

Kumai, T., "Estimation of natural frequencies of torsional vibratain of ships" (in English), Reports of Research Institute for Applied Mechanics, Kyushu Univ., Japan, **IV**, no. 13, 1955.

Kumai, T., "Shearing vibration of ships" (in English), Reports of Research Institute for Applied Mechanics, Kyushu Univ., **IV**, no. 15, 1955.

Kumai, T., "Some notes on the local vibrations of ships," Reports of Research Institute for Applied Mechanics, Kyushu Univ., **III**, no. 12, 1955.

Kurdivmov, A. A., "Ship vibration" (book published in Russian, 1953)

Leibowitz, R. C., "Natural modes and frequencies of vertical vibration of a beam with an attached sprung mass," TMB Rep. 1215, Sept. 1958.

Lewis, F. M., "Vibration and engine balance in diesel ships," *Trans. SNAME* 1927.

Lovett, W. L., "The vibration of ships," Shipbuilding and Shipping Record, Jan. 1927.

McGoldrick, R. T., "A study of ship hull vibration," EMB Rep. 395, Feb. 1935.

Mathewson, A. W., "Preparation of data for computation of vertical flexural modes of hull vibration by digital process," TMB Rep. 632, Sept. 1949.

Nicholls, H. W., "Vibration of ships," T.I.N.A., 1924.

Okabe, T., Hirata, K., and Kumai, T., "Vibration measurements of 32,000 D. W. Super Tanker" (in English), Reports of Research Institute for Applied Mechanics, Kyushu Univ., Japan, **IV**, no. 13, 1955.

Paladino, A. R., "Vibration survey on USS DECATUR (DD936)," TMB Rep. 1271, Jan. 1960.

Pavlenko, G. E., "A method of calculating ship vibration frequencies," *Engineering* June 25, 1926.

Ramsay, J. W., "Aspects of ship vibration induced by twin propellers," T.I.N.A., 1956; AMR **10**(1957), Rev. 2437.

Richards, J. E., "An analysis of ship vibration using basic functions," N.E.C.I. Trans. 1951.

Roop, W. P., "Natural frequencies of hull vibration," *Trans. SNAME* 1930.

Saunders, H. E., "Hydrodynamics in ship design," SNAME, 1957.

Schmidt, F., "Die Berechnung von Schiffschwingungen," WRH, Mar. 22 1930.

Sezawa, K., "The effect of the distribution of damping resistance in a ship on her vibration" (in English), *Zosen Kiokai J.* **66**, June 1940.

Taylor, J. L., "Ship vibration periods," N.E.C.I., 1927-28.

Taylor, J. L., "Vibration of ships," T.I.N.A., 1930.

Timoshenko, S., "Vibration problems in engineering," D. Van Nostrand Co., New York, 1937.

Tobin, T. C., "A method of determining the natural periods of vibration of ships," T.I.N.A., 1922.

Todd, F. H., "The fundamentals of ship vibration," *Shipbuilder and Marine Engine Builder* May, June, and July 1947.

Todd, F. H., "Ship vibration—A comparison of measured with calculated frequencies," N.E.C.I., 1933.

Todd, F. H., "Some measurements of ship vibration," N.E.C.I., November 1931.

Vane, F. F., "Shock and vibration in ships," in Handbook of shock and vibration control, Harris, C. M., and Crede, C. E., Editors, McGraw Hill Book Co. (to be published in 1961)

Wendel, K., "Hydrodynamische Massen und Hydrodynamische Massentragheitsmomente," STG Vol. 44, 1950 (also available as TMB Translation no. 260, July 1956); AMR **10**(1957), Rev. 1654.

Wilson, W. K., "A review of ship vibration problems," *Marine Engr. and Nav. Arch.* July, Aug., Oct., and Nov. 1955; also published in *ASNE J.* May 1954.

Physics, General

Book—3774. Holton, G., and Roller, D. H. D., Foundations of modern physical science, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958, xxiii + 782 pp. $8.75.

The book is recommended by the authors as a text for a one-year course in general physics for students majoring in the sciences (except physics and engineering) and in the arts, humanities, social studies and premedical curricula. It will also find an important use in physics courses for physicists and engineers in conjunction with certain other texts, and it is the reviewer's opinion that this book would be an extremely valuable one as supplementary reading for more advanced students in physics, chemistry and engineering.

Unlike conventional introductory physics texts, this book does not divide physics into the arbitrary division of mechanics, heat, sound, etc., but, in the words of the authors, "We let the historical and philosophical development of science suggest the organization and unification of the material." The nine parts into which the contents of the book are divided are then: I. Motion, II. Forces, III. Planetary systems, IV. Structure and method in physical science, V. Conservation principles, VI. Origin of atomic theory, VII. Fields in electricity and magnetism, VIII. Quantum physics of light and matter, IX. The nucleus. The stress within these divisions is on an understanding of the basic conservation principles including conservation of momentum, mass, energy and charge and the basic concepts of waves, fields, molecular structure of matter and structure of the atom. Thus the authors avoid encyclopedic coverage of physics and instead present a careful study of the important principles and concepts which includes an excellent discussion of the historical development of these underlying ideas,

and a portrait of some of the outstanding scientists that have contributed in a major way to their formulation. However, historical discussion is not included unless it helps to clarify the scientific ideas being discussed and therefore becomes a pedagogic aid. The authors have followed closely the pattern outlined by the recent Report of the American Association of Physics Teachers and in effect have implemented the recommendations of this association.

In the opinion of the reviewer, the text is an excellent one written in an exceptionally stimulating way. The introduction of certain historical aspects of science, including reproduction of pages from famous original scientific papers, is skillfully handled. Furthermore, the book is rich in excellent bibliographic material and in problems which not only emphasize an understanding of the textual material discussed but serve to introduce ideas beyond those treated in the text. Certainly there are omissions in the coverage of the book and many readers will regret some of these. However, the reviewer agrees with the philosophy of a treatment of fewer subjects in greater depth and with the balance of topics chosen and certainly recommends the text as a stimulating and challenging book for the college freshman and upperclassman as well.

R. E. Bolz, USA

Analytical Methods in Applied Mechanics

(See also Revs. 3791, 3795, 3799, 3800, 3801, 3807, 3808, 3810, 3813, 3814, 3819, 3849, 3922, 3927, 3931, 3970, 3972, 3996, 4041, 4044, 4048, 4083, 4129, 4143, 4197, 4263, 4272, 4280, 4298, 4305)

Book—3775. Sloan, R. W., An introduction to modern mathematics, Englewood Cliffs, Prentice-Hall, Inc., 1960, xi + 73 pp. $3.75.

This book does not at all bear directly on engineering theory or application. But in its 73 + xi pages it will introduce the reader casually and easily to many of the concepts and notations of modern mathematics—numbers versus names for numbers; mathematical logic, basic set theory, the modern concept of function, relation, and graph, as well as a brief word about the greatest integer, exponential and logarithmic functions.

Reviewer disagrees with publishers description "... a comprehensive treatment ...," "... a unique elementary presentation tion ...." There are many treatments appearing, just as elementary and much more comprehensive. However, for touching highlights in a clear, concise way with abundant examples, it gives a masterly presentation in the space allotted. Reviewer feels that, while not a significant book, it can be read through at a sitting and it will fulfill its function—to provide an introduction to modern mathematics. Any AMR reader out of touch with recent mathematical education will profit from perusing it.

J. F. Gray, USA

3776. Bhutani, O. P., A certain boundary value problem and its applications, *Appl. Scient. Res.* (*A*) **8,** 6, 413-424, 1959.

The problem considered is heat conduction in a long elliptic cylinder with zero initial temperature. Temperature on the surface is At^k (t, time; A and k constants), extending McLachlan's result for constant surface temperature [McLachlan, N. W., Theory and application of Mathieu functions, Oxford, 1951]. Solution, obtained by Laplace transform, is in form of quadruple infinite series of products of Mathieu functions and Bessel functions and, except for steady-state term which is given, a great deal of work would be needed to evaluate the solution for practical use. Applications to other problems governed by same equation are indicated: viscous incompressible flow in elliptic pipe, natural convection in vertical elliptic tube, eddy current loss in elliptic solenoid.

H. G. Landau, USA

3777. Quinlan, P. M., Fourier series for two-point boundary-value problems, AFOSR TN 59-744 (National University of Ireland, University College, Cork TN 8), 110 pp., Nov. 1959.

The general solution of the differential equation $F(D^2)z = g(x)$ is obtained in the form of a Fourier sine or cosine series. The result is expressed in terms of Fourier-Sum functions, involving two parameters K and θ, which are tabulated for $K, 0(.1)2$; $\theta/\overline{n}$, $0(.1)$, 1. The method is illustrated by numerical application to an eighth-order differential equation.

Since the solution is required, in practice, for only a limited number of discrete values of $\theta = \overline{n}\,x/L$, adequate tabulation in K and θ, to ensure five-figure accuracy, is quite feasible and the author plans to carry out this in the near future. The Fourier-Sum functions will then be as usable as the trigonometric functions, $\sin x$ and $\cos x$.

An alternative approach, based on convergence-improvement technique, is developed at length and illustrated by solving an eighth-order differential equation. This is especially suitable where the roots of the auxiliary equation are complex as, unlike other methods, it does not require to solve the auxiliary equation. The practicality of the method depends on having ready access to an electronic computer, as the number of simultaneous equations is somewhat increased.

By using the complex form of Fourier series the above methods are extended to the general equation $F(D)z = g(x)$. Extensive application, illustrated by worked examples, of Fourier-Sum functions is made to shear lag in box beams, beams on an elastic foundation, the stiffened suspension bridge, and the summation of even cosine and sine series.

Sixteen tables of Fourier-Sum functions are appended, and the extensions necessary to ensure five-figure accuracy for linear interpolation in K are discussed.

From author's summary

3778. Shimanov, S. N., A generalization of a proposition by Lyapunov on the existence of periodic solutions, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 2, 583-587, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Author considers a system $\dot{x} = Ax + X(x)$ and assumes that (a) the linear system $\dot{x} = Ax$ has m critical roots of the form $+N\lambda_i$ with simple elementary divisors and $m-1$ corresponding independent first integrals $M_k(x)$ being forms of first or second degree, (b) the complete system has $m-1$ first integrals of the form $M_k(x)$ + terms of higher degree. Then the system has a family of periodic solutions, depending on $n-1$ real parameters; the solution $x = 0$ is stable, and any solution, with initial values sufficiently small, tends, as $t \to \infty$, to one of the solutions of the family.

The theorem generalizes a proposition by Lyapunov concerning $m = 2$.

W. Hahn, India

3779. Mersman, W. A., Methods of calculating fundamental solutions of the wave equation, with tables, NASA TN D-86, 129 pp., Oct. 1959.

This report deals with the solution of $\dfrac{\partial^2 R_n}{\partial r^2} + \dfrac{1}{r}\dfrac{\partial R_n}{\partial r} - \dfrac{\partial^2 R_n}{\partial z^2} - \dfrac{n^2}{r^2} R_n = 0$, $R_n = R_n(z, r)$, where $(\partial R_n/\partial r) = 0$ at $r = 1$, $R_n = r^{-1/2}$ at $x = 0$ and $z = x + r - 1$. For computation, methods used are power series, finite differences and numerical solution of an equivalent integral equation. $R_n(x, r)$ satisfies $\int_0^\infty e^{-px} R_n(x, r)\,dx =$

$-e^{pr}K_n(pr)/pe^{p}K_n(p)$ where $K_n(p)$ is the modified Bessel function of the second kind. The cases $n = 0$ and 1 arise in supersonic flow problems. See, for example, the work of Ward [AMR **9** (1956), Rev. 196] and Miles [AMR **12** (1959), Rev. 3461] and the references given there. Tables are given for various r from 1 to 10 and for $n = 0(1)10$. The range on x is $0(0.02)10$ for $n = 0, 1$; $x = 0(0.02)7$ for $n = 2, 3$ and $x = 0(0.02)5$ for all other n. If $x \leq 1.5$, entries are to six decimals, otherwise four decimals.

Y. L. Luke, USA

3780. Cooke, J. C., Dual Fourier-Bessel series, *Quart. J. Mech. Appl. Math.* **12,** 3, 379–386, Aug. 1959.

A method is given for determining the coefficients a_n in the "dual" Fourier-Bessel series

$$\sum_{n=1}^{\infty} \alpha_n^{p} a_n J_\nu(\alpha_n r) = F(r) \qquad (0 < r < 1),$$

$$\sum_{n=1}^{\infty} a_n J_\nu(\alpha_n r) = 0 \qquad (1 < r < a),$$

where $-1 < p < 1$, $F(r)$ is specified and α_n is a positive root of $J_\nu(\alpha_n a) = 0$. Such series arise in the solution of potential problems in which the application of a finite Hankel transform is appropriate and in which one of the boundary conditions is a "mixed" one. As an illustration, the method is applied to find the potential due to an electrified circular disk situated inside an earthed coaxial infinite hollow cylinder. This shows that useful results can be obtained provided that the radius of the cylinder is sufficiently large.

From author's summary by A. I. van de Vooren, Holland

3781. Sundstrom, M., A special method for determining the power spectral densities of the solutions of linear differential equations with stochastic right member and coefficients consisting of polynomials in the independent variable, Roy. Inst. Technol., Stockholm, KTH Aero. TN 49, 7 pp., 1958.

Problem of determination of output spectral densities of linear time-varying systems is considered in the case when coefficients in system are polynomials. Solution is only presented in case when polynomials are linear. Vague comments are made about generalizations to higher-order polynomials, but the fact is that, in general, only when the polynomials are linear can the method be of any real value, since only in this case can the differential equation for the Fourier transform of the output be solved explicitly. In this case, however, paper is a trivial application, in bad notation, of well-known fact that the Fourier transform of a linear differential equation with linear coefficients is a linear, first-order equation.

M. Shinbrot, USA

Book—3782. Sedov, L. I., Similarity and dimensional methods in mechanics, (Translation from 4th Russian edition by Morris Friedman, edited by Maurice Holt), New York, Academic Press, Inc., 1959, xvi + 363 pp. $14.

This is a translation of a Russian book originally reviewed as AMR **11** (1958), Rev. 4822. The present reviewer agrees in general with the estimate of the contents given there but notes that with the increasing interest in magneto-fluid dynamics it will probably be necessary to include electrical quantities in future editions.

The translation is very good compared with one issued by a government agency (AD 141 869) and the format excellent by any standard. Perhaps if the effort expended in the two translations had been combined, a really outstanding translation would have been achieved. There are errors such as Strouhaille number for Strouhal number on pages 58 and 61 and the description of the coordinate θ as an amplitude on page 99 which could easily have been eliminated.

The book will be read with interest by research workers and will be interesting supplementary reading for courses in astrophysics, gas dynamics and partial differential equations. However, it does not seem suitable as a text for any standard course in American Universities.

W. Squire, USA

3783. Toralballa, L. V., The distribution of the dynamic life, *Aero/Space Engng.* **19,** 1, 57–60, Jan. 1960.

Discussion of the problem of obtaining the statistical distribution of the dynamic life of a unit taken from stock. This distribution would provide an answer to certain questions regarding the reliability of the given device. Author also describes a method for calculating the distribution of the dynamic life in a specific case.

From author's summary

Book—3784. Burnside, W., Theory of probability, New York, Dover Publications, Inc., 1959, ix + 106 pp. $1. (Paperbound)

This new Dover edition, first published in 1959, is an unabridged and unaltered republication of the 1928 edition. Ed.

3785. Kelley, J. E., Jr., A threshold method for linear programming, *Naval Res. Logist. Quart.* **4,** 1, 35–45, Mar. 1957.

Gerstenhaber (unpublished) has suggested a so-called "threshold method" for solving the transportation problem. This paper extends the method to the general linear programming problem. The idea is to concoct a vector function (depending on a positive parameter r) which maps a subset of vectors in the dual space onto a subset of vectors in the primal space in such a way that, if an image vector is feasible, then the associated value of the objective function differs from the optimum by at most r. The author lists postulates for such a mapping and exhibits a specific mapping satisfying the postulates. The computing procedure is still in the experimental stage, and no experience is reported.

A. J. Hoffman, USA

Courtesy Mathematical Reviews

Computing Methods and Computers

(See also Revs. 3805, 3809, 3816, 3915, 4044, 4053, 4054, 4141, 4210, 4242)

Book—3786. Lewis, C. I., and Langford, C. H., Symbolic logic, New York, Dover Publications, Inc., 1959, 518 pp. $2. (Paperbound)

This new Dover edition, first published in 1959, is a corrected and unabridged republication of the first edition published in 1932, to which appendix III has been added. Ed.

3787. Bauer, F. L., The formula-controlled logical computer "Stanislaus," *Math. Comput.* **14,** 69, 64–67, Jan. 1960.

A computer which will evaluate a truth function or logical formula with as many as eleven symbols and five variables has been designed and built by the author. The logical formula is entered in Warsaw notation (no parentheses) into a keyboard on the machine. The values of the five variables (1 or 0) are entered on toggle switches and the value of the truth function (1 or 0) is indicated by a panel light. A light also goes on if the formula entered on the keyboard is not well-formed. The machine was originally used for research in formula translation but is now used for demonstrations.

P. C. Patton, USA

3788. Ivlichev, Iu. I., and Nadzhafov, E. M., A universal pneumatic multiplier-divider and a square-root extractor, *Automation and Remote Control* **19,** 11, 977–988, June 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 11, 997–1009, Nov. 1958 by Instrument Society of America, Pittsburgh, Pa.)

Pneumatic analog computer, where inputs and outputs are pressures $P_1P_2P_3P_4$. Balanced bridge consisting of nozzle amplifiers insures relationship $P_1P_1 = P_3P_4$. It operates multiplication, division, square root, squaring. Three-place accuracy is claimed, with examples of actual performances.

Reviewer believes this is a new and useful device, although dynamic response is just sketched.

J. M. Loeb, France

3789. Brik, V. A., and Ginzburg, S. A., An analog computer realizing conformal mapping for an n-th order polynomial, *Automation and Remote Control* **19,** 7, 664–672, Apr. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 7, 674–683, July 1958 by Instrument Society of America, Pitrsburgh, Pa.)

An analog computer is described that makes it possible to analyze *n*th order polynomials ($n = 1, \ldots, 10$) with real and complex coefficients. The main purpose of the machine is to determine the roots of characteristic equations and plot Mikhailov loci.

From authors' summary

3790. Carden, G., Three analog computer circuits for the root locus, *Control Engng.* **7,** 4, 127–128, Apr. 1960.

Analogies

(See Revs. 3823, 4156, 4213, 4219, 4353)

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 3911, 3912, 3915, 4304, 4314)

Book—3791. Kane, T. R., Analytical elements of mechanics, Vol. 1, New York, Academic Press, Inc., 1959, xv + 250 pp. $4.75.

The book is the first of two volumes intended for courses in classical mechanics. It covers the elements of three-dimensional statics, using vector methods throughout.

Chapter titles are:- Vector algebra, Centroids and mass centers, Moments and couples, and Static equilibrium. The first chapter follows the normal sequence up to triple products, thoroughly if slowly. The second progresses from sets of points to curves, surfaces and solids. The third contains material that will probably be new even to students with a background in mechanics; it will presumably serve also as a basis for angular momentum in the forthcoming volume. The final and longest chapter begins by considering the gravitational attraction between two particles, then proceeds in stages to the equations of equilibrium; it includes sections on connected bodies and on friction but there is no mention of work theorems.

The presentation is clear. Diagrams and worked examples are numerous and helpful, and the book contains 143 problems, some with suggested solutions and all with answers. The author's contention that "the difficult task of relating physics to mathematics is facilitated by initially keeping the two separate in a clear-cut way" is reflected in the fact that force vectors, although used in examples throughout, become a part of general theory only in the final chapter.

Reviewer believes the book should do much to help the student's understanding of three-dimensional problems in mechanics. It should be found particularly valuable where the emphasis, as in the book, is analytic.

L. Maunder, Scotland

Book—3792. Landau, L. D., and Lifshits, E. M., Mechanics, Vol. 1, Theoretical physics [Mekhanika], Moscow, Gos. Izdat. Fiz.-Mat. Lit., 1958, 206 pp. 5.25 rubles.

The present volume is number one in the course on theoretical physics by the authors, to be completed in 9 volumes. The full set has been announced for publication in English translation.

The material covered is largely that which is traditional in a course on Newtonian mechanics at the level of the first-year graduate class, so that it does not seem necessary to give a detailed discussion of the various sections. However, since the pedagogical style adopted differs substantially from that of the usual American or English text, the reader may find it useful to see the list of chapters, with brief comments on points which seem most significant to the reviewer.

I. Equations of motion. II. Conservation laws. III. Integration of the equations of motion. IV. Collisions of particles. V. Small vibrations. VI. Motion of rigid bodies. VII. Canonical equations of motion.

The discussion commences at the level of Hamilton's principle and Lagrange's equations, without prior motivation. Only the simplest case of independent coordinates is treated explicitly, without consideration of constrained systems or nonholonomic systems. In addition to the usual topics of conservation of energy, momentum, and angular momentum, Chapter II includes a discussion of the virial theorem. The title of Chapter III may be misleading to a mathematician, since it suggests a general theory of integration whereas, in fact, only some of the usual special problems of particle mechanics, up to the two-body problem and Keplerian motion, are treated. In Chapter VI vectorial methods are employed to supplement the Lagrangian procedure. Chapter VII includes Hamilton's canonical equations, the Hamilton-Jacobi equation, and a brief consideration of the theory of adiabatic invariants. Throughout the text a number of special problems are given with solutions. In a few cases only the problems and answers are given.

The student who has had a good course in intermediate mechanics, up to Lagrange's equations, will find this text to be a very useful and clear statement of the major parts of classical mechanics. It is a little surprising to the reviewer that, with their emphasis on Lagrangian and Hamiltonian methods, the authors did not include a chapter on relativistic particle mechanics. From a wider point of view, it is somewhat disturbing to the reviewer that in this, as in other volumes of their course, the authors select carefully those parts of mathematical physics which are amenable to neat and precise formulation. While this is undoubtedly a great simplification for the beginning student, it should not be overlooked that the more important problems of principle in the interaction of mathematical and physical thought are almost wholly lost, so that the reader fails to gain any very clear notions either of the scope or the limitations of the theory.

E. L. Hill, USA

Courtesy of Mathematical Reviews

3793. Rosenauer, N., Vectorial interpretation of plane motion, *Instn. Engrs., Australia, Elect. Mech. Engng. Trans. EM* **1,** 2, 58–60, Nov. 1959.

Starting with the velocity vector of a moving point in a plane, which is the vectorial product of an angular velocity vector and a radius vector, expressions are derived for the "inflection circle" of zero normal acceleration and the "Bresse circle" of zero tangential acceleration. From these equations an expression for the location of the center of zero acceleration is obtained, and the Euler equation is derived. The use of this material is illustrated by an example of points on a rolling wheel subjected to acceleration.

A. H. Church, USA

3794. Hein, G., Analytical and graphical fundamentals for two and three positions of a link having spherical motion, as aids to the synthesis of spherical linkages, Parts I and II (in German), *Forsch. Geb. Ing.-Wes.* **25,** 3, 92–96; **25,** 4, 115–126, 1959.

The geometric relations pertaining to two and three finitely spaced or infinitesimally close positions of a link having spherical motion are established. Spherical motion means that all links —either pin- or slider-connected—move in concentric spheres (as different from planar motion where all links move in parallel planes). The relations parallel as closely as possible the ideas already developed for the coupler motion of planar linkages, as given in R. Beyer's "Kinematische Getriebesynthese." The analytical work is handled with spherical trigonometry. Various graphical constructions are given, such as bringing the construction into a tangential plane.

Among the concepts that are recast in spherical form are the center of rotation, instantaneous center, relative poles and pole triangles, circle through three points, R_M- and R^1-curves, Euler-Savary equation, inflection curve, and others. The Euler-Savary equation and the inflection curve developed here are similar to those given by R. Garnier ["Cours de Cinematique," Tome II, Paris 1956, pp. 110–116]. Some earlier (1913) conclusions drawn by W. Hartmann relating to certain details are considered to be incorrect.

The utility of the methods is demonstrated in several examples. Thus, four-bar linkages are proportioned to meet certain specifications such as coupler position, angular coordination between crank and follower, and the like. An example of a slider-crank with a specification relating to coupler-point motion is also presented.

R. S. Hartenberg, USA

3795. Chzhan, S.-l., The stability of motion of a gyroscope, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 3, 860–863, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Author considers the stability of motion of a free gyroscope in a uniform gravity field with axis of the outer gimbal horizontal and axis of the inner gimbal initially vertical. Gimbal inertias are taken into account. A necessary condition for stability in the sense of Lyapunov is found by application of a theorem due to Chetaev. This necessary condition takes the form

$$Cr_0^2 > mg\,\rho\,\{(J + 2A + A' + B') \pm 2\,[(J + B' + A)\,(A + A')]^{1/2}\}$$

where A, C are principal rotor moments of inertia; A', B', C' principal inner gimbal moments of inertia; J the outer gimbal moment of inertia; r_0 the spin rate; mg the rotor weight; ρ the distance from the position of the mass center of the rotor on the symmetry axis to the geometrical center of the system.

Reviewer notes that work of Plymale-Goodstein [AMR **9** (1956), Rev. 2106] implies that for $\rho = 0$ and gimbals not initially perpendicular this condition cannot be sufficient to ensure stability. The word "determinable," p. 862 line 2, should read "definite." There is also a misprint in the basic result. This has been corrected above.

L. E. Goodman, USA

3796. Research in automobile stability and control and in tire performance, *Proc. Instn. Mech. Engrs., Auto Div.* no. 7, 287–426, 1956/7.

A collection of five papers presents results of research in automobile stability and control and in tire performance, carried out in Cornell Aeronautical Laboratory, U.S.A.:

(1) General introduction to a programme of dynamic research, by W. F. Milliken and D. W. Whitcomb.
(2) Theoretical prediction of experimental substantiation of the response of the automobile to steering control, by L. Segel.
(3) A device for measuring mechanical characteristics of tyre on the road, by W. Close and C. L. Muzzey.
(4) Tyre tests and interpretation of experimental data, by A. G. Fonda.
(5) Design implications of a general theory of automobile stability and control, by D. W. Whitcomb and W. F. Milliken.

Part 1 is a general introduction giving an historical background of the problem and showing the great advantages derived utilizing aeronautical and control-theory techniques in deriving equations of motion of the automobile.

Part 2 deals with the development of a mathematical model for a pneumatic tire vehicle, which is used to represent the lateral rigid-body motion produced by steering control. The validity of derived equations is substantiated by full-scale tests made with an instrumented vehicle.

Part 3 describes the tire tester developed by C.A.L. which, it is claimed, is the only one measuring all six components of load, i.e. the three moments and the three forces acting on the tire.

Part 4 gives an account of tests performed using the C.A.L. tester. Data analysis is based on the notion of derivatives as used in aircraft stability analysis and upon a simple tire theory derived in an appendix.

The above was carried out for camber variations from $+30^\circ$ to -30° and for steer variation from $+30^\circ$ to -30°, which ranges are unprecedented.

Part 5. "The lateral-directional motions of an automobile are studied by means of equations of motion derived for a vehicle assumed to have yawing and side-slip degrees of freedom only, and traveling at a constant forward speed. The equations are presented in terms of the automobile stability derivatives." (from author's summary).

This collection of five papers is a very valuable contribution to the analysis of performance as well as to the design of motor cars.

J. Solvey, Australia

3797. Mirkeyev, A. O., The motion of a perfectly-flexible and elastic filament over a rough surface (in Russian), *Uch. Zap. Gor'kovsk. In-ta* no. 28, 70–78, 1955; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8379.

The tensile stresses T in points of a perfectly flexible and elastic, homogeneous, imponderable filament moving along itself over a rough surface are determined. The stress-strain relationship is represented by a broken-line curve consisting of two rectilinear segments. Calculation of the stresses requires knowledge of the velocities and tangential accelerations at all points on the filament. As examples, the tensile stresses are determined for the uniform motion of an inelastic (inextensible) filament along the geodetics of atoms and a cylinder, respectively. For the particular case of a filament at rest on a rough circular arc the known formula of Euler is obtained for the tensile stress.

The impact stresses, which arise in an inextensible (inelastic) filament sliding along a geodetic on a rough surface, are determined for the case of an impact force applied at the point of entry of the filament onto the surface, and for the case of gripping of the filament at any point on the surface. The paper contains clerical errors.

P. A. Zhuravlev

Courtesy Referativnyi Zhurnal, USSR

3798. Kazak, S. A., The determination of the analytical value of the angle of maximum deflection of a swinging load (in Russian), *Sb. Statey Ural'skogo Politekhn. In-ta* no. 56, 20–22, 1955; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8402.

The problem discussed is that of the actual deflection of a moving load in oscillating systems, such as may occur in the case of accidental, unfavorable conjunctions of the time instants of starting one establishment of steady-state motion, and the instant of retardation of the point of suspension of the load. It is assumed that at the initial time instant, the load is in the same vertical as the suspension point, and that the displacement of the suspension point proceeds along a horizontal line. If the starting time frequency t_n and the braking time frequency $t\tau$ are equal to (or greater than) the semi-period $\frac{1}{2}T$ of the free oscillation of the load, then, during the retardation period, considerable swinging

of the load may take place, with a maximum angle of deflection from the vertical of

$$\varphi_{max} = 2 \arctan \frac{a_n}{g} + 2 \arctan \frac{a_\tau}{g};$$

wherein a_n is acceleration in the starting period, a_τ acceleration in the braking period, g the acceleration of gravity. Author considers such a case to be the standard, and the loads produced thereby in the suspension point to be fortuitous.

M. P. Gulyaev
Courtesy Referativnyi Zhurnal, USSR

Book—3799. Lefschetz, S., edited by, Contributions to the theory of nonlinear oscillations, Vol. IV, Princeton, N. J., Princeton University Press, 1958, 211 pp. $3.75. (Paperbound)

The present volume, as its predecessors [Vol. 1: AMR **4** (1951), Revs. 555, 556, 559, 1932, 3750, 3751, 3787; Vol. 2: AMR **6** (1953), Revs. 700, 704, 743, 1501, 2400; Vol. 3 not reviewed in AMR) is a collection of (ten) papers dealing with various topics related to nonlinear differential equations. Presentation, and to some extent also the topics, are clearly intended for mathematicians. This is true also of the papers (such as the third and eighth below) which are of potential interest to the engineer.

The first paper, by S. Kakutani and L. Markus (On a nonlinear difference-differential equation), deals with an equation of the type $y' = fy$. When f is constant it describes a birth process with constant birth-rate f in a population y. In this paper, the birth rate is assumed to depend linearly on $y(t - \tau)$, the size of the population of the preceding generation. Existence and properties of solutions are discussed. In particular, asymptotic behavior and oscillatory nature are studied.

The second paper, by S. Lefschetz (On the critical points of a class of differential equations), treats the phase-plane portraits of the most general second-order nonlinear system with the following property: Its linearized version does not vanish identically but the characteristic roots of the latter are both zero. An open problem concerning the nature of the possible periodic solutions of the system is resolved.

The third paper, by D. Bushaw (Optimum discontinuous forcing terms), presents the first successful solution to a well-known engineering problem, namely, the design of the optimum switching functions for discontinuous automatic control. Given: a second-order system. It is desired to find a forcing function, depending on y and y' and taking only two values (bang-bang control) which returns the system to its equilibrium point in the shortest time starting from any given initial conditions. A general property of optimal switching functions is first derived. Construction of the optimum switching function is outlined for the case when the given system is linear.

The fourth paper, by R. DeVogelaere (On the structure of symmetric periodic solutions of conservative systems with applications) studies a problem concerning the periodic orbits of a charged particle in a magnetic field and, more generally, concerning the periodic solutions of conservative (non-dissipative) dynamical systems. Following Poincare and G. D. Birkhoff one can often represent the given dynamical system by a transformation of a certain surface into itself under which the periodic orbits emerge as fixed points. In this paper, the idea is generalized and leads to a method for the classification of these orbits according to their geometrical properties. Numerical computations of a special case are exhibited.

The fifth paper, by D. L. Slotnick (Asymptotic behavior of solutions of canonical systems near a closed unstable orbit) is concerned with conservative dynamical systems of two degrees of freedom, and more particularly with the instability of its closed orbits. If such an orbit is known, it can be transformed into the equilibrium solution of a related system, and the problem now concerns the stability of the equilibrium of the new system. It can happen that the linearized version of the new system indicates stability when the complete system is in fact unstable. This case is discussed in the paper. Several results concerning local instability are established.

In the sixth paper (Small periodic perturbations of an autonomous system of vector equations), W. T. Kyner applies a fixed-point theorem proved by him previously (these contributions, Vol. III) to the question of whether or not the existence of periodic solutions is preserved in a nonlinear system under small perturbations. The answer is affirmative.

G. Seifert, in the seventh paper (Rotated vector field and an equation for relaxation oscillations), continues his earlier work (these contributions, Vol. III.). The method of rotated vector fields is applicable to second-order systems, and is used for the determination of the existence and stability of periodic solutions. The method is extended in this paper. It is then used to prove the sufficiency of a set of five conditions for the existence of a stable periodic solution of a relaxation oscillator.

The eighth paper, by H. A. Antosiewicz (A survey of Lyapunov's second method), is a highly condensed review of recent work on the so-called second or direct method of Lyapunov. This is a method by which one can sometimes verify the stability or instability of the equilibrium of a given linear or nonlinear system. It has received considerable attention, especially in the USSR, by workers in the field of control systems. In this paper, nine definitions of "stability" are first given. The three most important are selected, and twenty-five theorems concerning them are presented and proven. A bibliography of 53 items is added which does not, however, contain references to practical applications.

P. Mendelson in the ninth paper (On phase portraits of critical points in n-space) deals with a problem that is more general in one respect than the one treated in the second paper, and more special in another: The system is n-th order with a nonvanishing linearized form but the latter has only one vanishing characteristic root. The real parts of the other are of the same sign. A careful discussion is made of the geometrical nature of the solutions near the equilibrium point.

The concluding paper, by R. W. Bass (On nonlinear repulsive forces), deals with systems of second-order differential equations with an unstable equilibrium point. It extends the validity of a known result concerning the solutions of such systems, namely, that at any starting point two special trajectories exist, one going to infinity and the other passing through the equilibrium point. The initial velocity determines whether the system follows either of these trajectories and which one.

R. F. Drenick, USA

3800. Faure, R., Strongly nonlinear oscillations in the neighborhood of the Lienard cycle (in French), *Rev. Tijdschr.-Mecan. Werk.* **5**, 1, 21–26, 1959.

Paper is a résumé of another paper not yet published. Author considers the differential equation:

$$\mu \ddot{x} + f(x)\dot{x}\, t\mu g(x) = 0$$

having a limit cycle for $\mu \to 0$.

He proposes a method of successive approximations to calculate this limit cycle when $\mu \neq 0$. The result is applied to Van der Pol's equation.

D. Graffi, Italy

3801. Yamamoto, T., Stability criteria for and response function of forced vibration in non-linear systems, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur; 1957, 251–258.

General nonlinear systems with forced vibrations, as represented by the equation $\ddot{x} + p^2 x + \varepsilon f(x, \dot{x}) = F \sin \omega t (F > 0)$ where εf is a nonlinear term, are studied by a method similar to that used by

A. Andronov and A. Witt for van der Pol's equation. The phase of the solution, rather than the phase of the disturbing force, is fixed by rewriting the above equation in the form $\ddot{x} + p^2 x + \varepsilon f(x, \dot{x}) = F_1 \sin \omega t + F_2 \cos \omega t (F_1^2 + F_2^2 = F^2)$. The response function for this system is then found to be representable in the form $\Phi = [(p^2 - \omega^2)a + \varphi_1]^2 + \varphi_2^2 - F^2 = 0$, where a is the amplitude of the forced vibration, and

$$\varphi_1 = \frac{1}{\pi} \int_{-\pi}^{+\pi} \varepsilon f(a \sin \theta, a\omega \cos \theta) \sin \theta \, d\theta$$

$$\varphi_2 = \frac{1}{\pi} \int_{-\pi}^{+\pi} \varepsilon f(a \sin \theta, a\omega \cos \theta) \cos \theta \, d\theta.$$

It is found that stability is ensured if $\frac{\partial \Phi}{\partial a} > 0$, $\frac{\partial (a\varphi_2)}{\partial a} > 0$.

L. Beaubien, USA

3802. Ishlinsky, O. Yu., Damping of motions with high acceleration (in Ukrainian), *Prikl. Mekhanika* **3**, 2, 131–139, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9308.

It is shown in general form that damping is suitably applicable only in the case when the braking length of the body carrying the object is less then the working stroke of the damper or shock-absorber to be used. Numerical examples are adduced, showing the advisability of using damping for the protection of instruments against shock when the braking length is small, and the preeminence of rigid attachment of instruments to their bases, without shock-absorbers, if the braking length is greater than the maximum available stroke of the shock-absorbers. Yu. I. Iorish

Courtesy Referativnyi Zhurnal, USSR

Instrumentation and Automatic Control

(See also Revs. 3781, 3788, 3795, 3796, 3799, 4305, 4377)

Book—3803. Chestnut, H., and Mayer, R. W., Servomechanisms and regulating system design, Vol. 1, 2nd ed., New York, John Wiley & Sons, Inc., 1959, xvii + 680 pp. $11.75.

The first edition of this book was reviewed in AMR **5** (1952), Rev. 2278. Major changes in the second edition are the addition of material on the root-locus technique, and a chapter on analogue computing, which is adequate for the limited aims set forth by the authors. There is also a useful collection of charts relating transient to harmonic response. The rest of the book is made up of the classical theory of servo systems, viz. Laplace transforms, stability theory, Nyquist diagrams, attenuation-phase plots, etc.

Very little initial knowledge is presumed on the part of the reader, as the book includes an elementary chapter on complex number theory. (What sort of student is it, one wonders, who is not supposed to know complex numbers, yet requires no explanation as to synchros or amplidynes?) In the early chapters particularly, rather over-abundant and verbose explanations are given of the simplest matters, and these are made worse by a phraseology which is often clumsy and loose, and sometimes absurd, as for instance "Rotary motion is defined by Newton's second law of motion as the angular acceleration of a body, which ... is proportional to ... the applied torques and inversely proportional to the moment of inertia ...".

Several definitions are rather weak. Most conspicuous is the absence of any definition of linearity (not by any means an obvious concept, since it is usually taken to imply invariance of parameters with time as well as applicability of the superposition principle). The astonishing statement is made (p. 76) that finite time delays do not occur in truly linear systems. Elsewhere we find that "the superposition principle can be used only .... in systems with linear coefficients," whatever that may mean.

Some of the examples given in the earlier chapters are ill-found. Thus dashpots are drawn with unbalanced areas (p. 193). Hydraulic motor servos are analyzed with allowance for oil compressibility, and hydraulic cylinder servos without, although the effect is normally much more serious with the latter—indeed this is one of the chief reasons for using hydraulic motors.

The chapter on Laplace transforms makes no mention of the convolution theorem.

The quality of the book improves however as it proceeds, and the painstaking detail, and wealth of worked examples, should succeed in driving the point home to the student. One surprising feature however is the absence of any mention of the usual technique with Nichols charts, viz. replotting attenuation versus phase on the chart. Instead, the book advocates the much more laborious process of replotting a number of M contours on the attenuation-phase diagram. R. Hadekel, England

3804. Jawor, T., Using the root locus, Parts I and II, *Control Engng.* **6,** 10, 96–102, Oct. 1959; **6,** 11, 119–122, Nov. 1959.

In Part I the author gives an example of applying the root-locus method to a controlled process consisting of a first-order lag and a distance velocity lag (i.e. transport time delay) which is controlled by a three-term noninteracting controller. The design criterion used was the specification of the damping ratio and settling time of the dominant closed loop pole. Imposition of these conditions determined the three constants of the controller. In leading up to this example, the author reviews the root-locus technique in detail and even repeats the standard root-locus construction rules.

Part II is concerned with finding the coefficients in the response of a system to step and impulse inputs, using the root locus. The observation is also made that the response to step or impulse disturbances which enter at various points in the loop can be analyzed in the same way if the system is re-arranged so that the disturbance looks like an input to the re-arranged system.

While a great deal of the material in this paper can be found in "Control system dynamics" by W. R. Evans [McGraw-Hill Book Co., Inc., N. Y., 1954], the paper is well written and should provide interesting reading for one interested in the application of the root-locus method to a few simple examples.

H. E. Lindberg, USA

3805. Atsiukovskii, V. A., Logarithmic method of plotting real frequency response of an automatic control system, *Automation and Remote Control* **19,** 11, 1045–1048, June 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 11, 1073–1076, Nov. 1958 by Instrument Society of America, Pittsburgh, Pa.)

Evaluation of roots to three significant figures, if plotting is accurate, is possible by this method, according to author. Using tables of logarithms of sums and differences computed by Gauss, the logarithm of each term of numerator of the real frequency response is taken separately and plotted with log ω as abscissa; these are added at various points. Similar calculations and plotting are performed for each term of denominator, and logarithms are again added at various values of ω. Subtracting the denominator summation from the numerator summation at the various values of ω, the logarithm of the system's real frequency response as a function of ω is obtained. R. L. Sutherland, USA

3806. Birch, B. J., and Jackson, R., The behaviour of linear systems with inputs satisfying certain bounding conditions, *J. Electronics Control* **6,** 4, 366–384, Apr. 1959.

A method is described for obtaining the least upper bound of the output [of a stable linear filter] for the case where bounds are specified both for the magnitude of the input and its rate of change. The result, which is obtained in the form of a procedure for con-

structing that input (satisfying the bounding conditions) which gives rise to the largest output, has applications in the design of automatic control systems.

From authors' summary by N. J. Rose, USA

3807. Kurakin, K. I., An analytical method of synthesis of linear control systems in the presence of interference and with a specified dynamic accuracy, *Automation and Remote Control* **19,** 5, 402–412, Mar. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 5, 408–417, May 1958 by Instrument Society of America, Pittsburgh, Pa.)

An analytical method of approximation of transcendental transfer functions of automatic control systems is proposed. The functions were obtained with the help of fraction-rational functions. Several illustrative examples point out the practicability of the proposed method of approximation, including its application to the solution of problems in the optimization of automatic control systems, in the presence of interference and with given requirements for dynamic accuracy.

From author's summary by V. Chobotov, USA

3808. Vasil'ev, V. G., On the relationships between the error coefficients and the amplitude and phase characteristics of linear reproducing systems, *Automation and Remote Control* **19,** 5, 469–471 (Letters to the Editor), Mar. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 5, 475–477, May 1958 by Instrument Society of America, Pittsburgh, Pa.)

Reference is made to a paper by A. M. Boev where the question of the interrelationship of the error coefficients and the system's frequency characteristics (imaginary, real and amplitude) was dealt with. It is stated, however, that in Boev's paper the interrelationship of the error coefficients and the system's phase characteristics remained unexplained. The present note establishes the character of such a relationship. Expressions were obtained relating the error coefficients with the Cauchy coefficients for the system's amplitude and phase characteristics.

V. Chobotov, USA

3809. Mikhailov, N. N., Plotting of root loci of automatic control systems, *Automation and Remote Control* **19,** 7, 652–663, Apr. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 7, 661–673, July 1958 by Instrument Society of America, Pittsburgh, Pa.)

Analytical, graphical, and semigraphical plotting of root loci of automatic control systems is briefly discussed, as is the use of semiautomatic and automatic root-finders; the latter device is limited by inability to determine loci for systems having transfer functions containing zeros. Several block diagrams of automatic root-locus plotting devices are proposed, all utilizing cathode-ray tube and counting circuits, with variations. Author states that these can also be used to obtain root loci resulting from variations of parameters other than amplification factor, and to plot families of phase loci.

R. L. Sutherland, USA

3810. Rutkovskii, V. Iu., Analysis of free oscillations about its center of gravity of a neutral plane without damping of its own and with a relay autopilot, *Automation and Remote Control* **19,** 5, 430–441, Mar. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 5, 435–447, May 1958 by Instrument Society of America, Pittsburgh, Pa.)

A relay system, the linear part of which is described by the simplest degenerate third-order equation, is considered. The control system's dynamics are analyzed by means of the method of point transformation of surfaces, which enables one to show all the possible modes of movement in it, including the sliding modes. The analysis yields the equations of surfaces determining the region of attraction (by the initial conditions), equilibrium state, and the stable limiting cycle. These equations may serve as criteria in the choice of the regulator's parameters, under given restrictions, from a coordinate and two of its derivatives.

From author's summary by V. Chobotov, USA

3811. Komarnitskaia, O. I., Stability of nonlinear automatic control systems, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 3, 716–729, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Let the equations of the control system be given in the canonical form $\dot{x}_i = \lambda_i x_i + f(s)$, $\dot{s} = \sum b_i x_i - rf(s)$. Object is to obtain conditions for the parameters λ_i, b_i, r which grant the stability of the system, the nonlinearity $f(s)$ being fixed and so that $f(0) = 0$, $sf(s) > 0$ $(s \neq 0)$. There are some methods due to Lur'e and Malkin, using Lyapunov functions. Author discusses Malkin's method and the choice of a suitable Lyapunov function in several special cases. The results are not as good as the results yielded by Lur'e's method, which gives a wider range of stability in the space of the parameters, but Malkin's method can more easily be extended to a higher number of degrees of freedom and also to some critical cases (some roots $\lambda_i = 0$).

As usual, no numerical example has been given.

W. Hahn, India

3812. Spassky, R. A., A particular class of controlled systems (in Russian), *Uch. Zap. Vyborgsk. Gos. Ped. In-ta* **2,** 3–14, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8404.

The general case is investigated of a nonlinear controlled system for which the characteristic equation of the "linear part" has a zero root of arbitrary order. The system is reduced to the classical form. The stability of the system is determined by Lyapunov functions. The particular feature of the analysis consists in that the restricted domain of the phase space is resolved into two regions, in one of which the derivative of the Lyapunov function is zero; and in the other is positive. A generalized method is given for determining the conditions sufficient for the asymptotic stability of this particular form of controlled systems.

E. P. Popov

Courtesy Referativnyi Zhurnal, USSR

3813. Pervozvanskii, A. A., Approximate method of analysis of self-excited systems in the presence of random disturbances (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 14–24, Mar. 1958.

The system under consideration consists of one nonlinear element in addition to the linear elements. It is assumed that the closed-loop system is unstable. The method of statistical linearization has been used for the analysis when the random disturbances occur. It is assumed that the filtering in the linear elements is sufficient to eliminate the distortion of the probability distribution of the Gaussian input by the nonlinear element.

It is shown that the characteristics of the input disturbance influence the amplitude and frequency of the self-excited oscillations. Under certain conditions the oscillations can even be eliminated. The equivalent gains have been determined for some typical nonlinearities with the disturbances of a more restrictive kind.

An example of a relay-type closed-loop system has been analyzed by the method developed and results of the experiments on an analog computer have been given. The performance of an electronic oscillator in the presence of the random disturbance has also been investigated.

M. Mesarovic, USA

3814. Pugachev, V. S., Integral canonical representation of random functions and their application in the determination of optimum linear systems (in Russian), *Avtomatika* **18,** 11, 971–984, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8413.

A description is given of the integral, canonical representation of random functions expressed in terms of the backlash and weight function of a particular linear system. A differential equation is presented for determining this weight function. The aforesaid integral, canonical representation of a random function is applied to the calculation of the optimum, linear operator by the criterion of the minimum mean square error, or by the criterion of the extreme value of a given function of mathematical expectation and dispersion of error. Contrary to the method of canonical resolutions, furnishing the optimum linear operator in the form of a series, the solution is in this case obtained in closed form; but the range of problems accessible to the method is more limited. Examples are given.

E. P. Popov

Courtesy Referativnyi Zhurnal, USSR

3815. Mullin, F. J., The analysis and compensation of nonlinear sampled-data feedback systems, AFOSR TN 58-825 (Univ. Calif., Dept. Electrical Engng. Series 60, no. 211; ASTIA AD 202 910), 121 pp., Aug. 1958.

Simple closed loop comprises hold element, amplitude nonlinearity, second-order linear element. (a) For relay-type nonlinearity, step, ramp, and frequency responses are found by phase-plane method. (b) Stability of system with saturation nonlinearity is investigated using (i) piecewise-linear, (ii) power-series, approximation. (c) Compensation method for saturating system uses discrete pulses to force error to zero within finite time.

Report contains much interesting material, but swarms with misprints.

N. Ream, England

3816. Lefkowitz, I., and Eckman, D. P., Application and analysis of computer control system, *ASME Trans.* **81** D (*J. Basic Engng.*), 4, 569–576, Dec. 1959.

The electronic computer offers the possibility of achieving complete and precise control of physical systems. An application of particular interest is the computer control of industrial processes to specified criteria of performance; e.g., control of the process such that product of uniform, specified quality is produced under conditions of minimum cost.

A computer control application to a batch-type process is presented. The method of control, based on repetitive computer action and fast-time scaling, makes it possible to obtain a specified end point consistent with a prescribed criterion of optimum performance.

Dynamic analysis of the computer control system is difficult because of the nonlinear and sampled-data characteristics of the computer element. A method for approximate determination of system behavior based on perturbation techniques is described. It is shown, in particular, that the effect of a disturbance signal on the processing path varies in almost direct proportion with the sampling period. Thus, by making the sampling period small relative to the duration of the process, simplifying approximations to the mathematical model may be employed in the derivation of the computer-control equations.

The study is augmented by data on computer control of a three-component-batch chemical process. The results of the dynamic analysis are compared qualitatively with the experimental results of predictor and optimizing control runs.

From authors' summary

3817. Thaler, G. J., Analysis and stabilization of sampled data systems, *Control Engng.* **7,** 1, 123–124, Jan. 1960.

3818. Eggleston, J. M., Baron, S., and Cheatham, D. C., Fixed-base simulation study of a pilot's ability to control a winged-satellite vehicle during high-drag variable-lift entries, NASA TN D-228, 60 pp., Apr. 1960.

A winged-satellite vehicle which enters the atmosphere at high (approaching 90°) angles of attack was simulated in five degrees of freedom by using a fixed-base simulator. The task of controlling the vehicle and the vehicle's trajectory during the entry was performed by a human pilot. Variations of the pilot's task, the static and dynamic stability, control effectiveness, and the effects of adverse coupling of aerodynamic control moments were investigated.

From authors' summary

3819. Gorskaia, N. S., The influence of linear zones and regions of saturation on the dynamics of two-stage servomechanisms, *Automation and Remote Control* **19,** 5, 413–429, Mar. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 5, 418–434, May 1958 by Instrument Society of America, Pittsburgh, Pa.)

The dynamics of the free motion of a two-stage servomechanism are investigated, where the first stage has a relay controlling element whose characteristics contain a loop and a dead zone, and the second stage contains a controlling element with a linear zone and with saturation regions. The investigation is carried out by the method of point transformations.

A complete study is made of the nonlinear problem involving the influence on the free oscillations of the servomechanism of the second stage characteristic with the linear zone and the regions of saturation. Analytic expressions are given for the critical values of the basic servomechanism parameters.

From author's summary by V. Chobotov, USA

3820. Cheatham, D. C., Young, J. W., and Eggleston, J. M., The variation and control of range traveled in the atmosphere by a high-drag variable-lift entry vehicle, NASA TN D-230, 41 pp., Mar. 1960.

A study has been made of the variation of range traveled during the atmospheric entry of a high-drag variable-lift type of entry vehicle. The effect on range of such factors as entry angle, angle of attack, wing loading, initial velocity, orbital heading, and initial latitude was investigated. Results are also presented which show the feasibility of an automatic control which regulates angle of attack in such a manner as to control the trajectory of the vehicle to a desired landing area. Results using this method of range control show that the range could be controlled to within ±20 miles of the desired location by the time an altitude of 100,000 feet is reached.

From authors' summary

3821. Nightingale, J. M., A new design concept for controlling control-systems: self-optimizing servo circuits, *Mach. Design* **32,** 1, 139–143, Jan. 1960.

3822. Otto, K. A., Updating design procedures for surge vessel control systems, *Control Engng.* **6,** 12, 106–110, Dec. 1959.

3823. Felix, B. R., and Bohl, R. J., Dynamic analysis of a nuclear rocket engine system, *ARS J.* **29,** 11, 853–862, Nov. 1959.

After a preliminary definition of transient regimes of nuclear rocket engine operation, authors list the basic control requirements for such an engine. Subsequently, they formulate a mathematical model of the system which expresses the transient behavior of the nuclear reactor, heat-exchange equipment, feed system pump, hot gas valve and gas turbine. Electronic analog representation of these equations is presented. Graphs are attached showing the effect of step reactivity changes on fuel element temperature and on neutron flux level as obtained from analog simulation. In addition, frequency response graphs are attached for the same parameters in dimensionless form, obtained by a highly simplified analytical derivation.

Reviewer believes that this paper has mainly engineering significance insofar as it points to the order of magnitude of several effects which determine the design of control system for a nuclear rocket engine. The mathematical analysis of various components is standard and is mostly borrowed from existing references. This reviewer believes that within the approximations of this paper the

mathematical analysis of the reactor could be simplified by averaging the lifetimes of delayed neutrons to two groups and by neglecting the diffusion terms of radioactive precursors. On the other hand it is felt that the mathematical description of thermal and pumping parts of the system is over-simplified. Similarly, no delay terms, which inevitably occur in a heat-transfer system involving nuclear reactors as well as those which are due to the time lag between sensors and control elements, are included.

Authors are obviously acquainted with a substantial literature of recent origin dealing with dynamic characteristics of various elements of the system in a more thorough and exhausting way than theirs. This reviewer performed in 1954 [Curtiss-Wright Atomic Div., Aircraft Nuclear Propulsion Study Summary Rep. 1840, 1954] an analog simulation of a system, similar to that of authors, considering much more complex mathematical model, including transportation delays due to flow, control saturation effects, nonlinearities of reactivity, performance maps of actual pumps, turbines and nozzles, etc. Similarly, a difference scheme has been applied to simulate effects of geometry, which are averaged out in this paper. This work was performed using the vast analog computing facilities of Wright Field in Dayton, Ohio. It was possible to analyze the effect of step changes of a number of parameters including reactivity, flow rates, power demands, etc.

It would be useful if notation of present paper could be more uniform and consistent. Some symbols are not explained, others have dual meaning. Table 2 contains summary of formulas, some of which contain time derivatives, others are in the form of Laplace transforms. Integrals of certain differential equations are quoted without derivation, where constants appear, whose relevance is difficult to understand in the context of the discussion (for example in the integral of precursor density.) It would also be very useful if the formulas were denoted by numbers.

B. Zarwyn, USA

3824. Perel'man, I. I., Control based on the principle of a self-adjusting program, *Automation and Remote Control* **19,** 9, 797–807, June 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 9, 813–823, Sept. 1958 by Instrument Society of America, Pittsburgh, Pa.)

This paper and following review describe design analysis of automatic thickness controls for steel sheet rolling mills. Liberal references to pertinent U. S. A. literature are included.

R. M. Stewart, USA

3825. Velershtein, R. A., and Fel'dbaum, A. A., Development of an almost optimal system by means of an electronic analog, *Automation and Remote Control* **19,** 9, 808–818, June 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 9, 824–835, Sept. 1958 by Instrument Society of America, Pittsburgh, Pa.).

See preceding review. R. M. Stewart, USA

3826. Kampe-Nemm, A. A., The application of a thermoelectric proportional-plus-integral corrective device for improvement of two-position temperature control, *Automation and Remote Control* **19,** 5, 461–463, Mar. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 5, 468–470, May 1958 by Instrument Society of America, Pittsburgh, Pa.)

An automatic control method which is based on application of a thermoelectric corrective device and combines the properties of two-position and proportional-plus-integral control is treated. The construction of the corrective device is described. Experimental results show that the proposed device permits a substantial improvement of the two-position control process.

From author's summary

3827. Friebel, M., Considerations on pressure control in steam generators (in German), *Automatisierung: Z. Messen, Steuern, Regeln* **2,** 1, 25–29, Feb. 1959.

Author presents the results of a limited analytical study of the possibility of combustion control of boilers. It is shown that drum pressure control is limited by the ratio of firing time constant to boiler residence time. Within these limits, drum pressure can be controlled by a proportional-type regulator and droop can be eliminated by the use of reset. Even if the drum pressure is controlled, the pressure at the superheater outlet will not be constant.

M. A. Mayers, USA

3828. Gintsburg, I. P., The fundamental dynamic equations of hydraulic-turbine governing (in Russian), *Uch. Zap. LGU* no. 217, 144–184, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8424.

Article contains the detailed derivation of the equations of the governing process in hydraulic turbines equipped with a hydraulic governor. Equations are set up for: the turbine to be governed, the sensitive element, the servomotors, distribution valves, and feed pipes. The equations obtained are compared with those given in the fundamental work of A. Stodola on turbine governing. The equations obtained are not further analyzed.

M. A. Aizerman

Courtesy Referativnyi Zhurnal, USSR

3829. Hovorka, J., Hursh, J. W., Frey, E. J., Denhard, W. G., Grohe, L. R., Gilinson, P. J., Jr., and Vander Velde, W. E., Recent progress in inertial guidance, *ARS J.* **29,** 12, 946–957, Dec. 1959.

Paper gives a brief, nonanalytical but highly interesting survey of current problems in inertial guidance reflecting experience from the pioneering work at the Instrumentation Laboratory at MIT, and discusses existing and suggested solutions. After an introduction by Hovorka, following topics are discussed: recent development in airborne inertial systems (Hursh), application of inertial navigation to ballistic missile guidance and launch guidance of space vehicles (Frey), gyros used in inertial navigation (Denhard), accelerometers (Grohe), electromechanical components used in inertial navigation (Gilinson), computer subsystem (Vander Velde), marine inertial navigation (Hovorka).

F. Y. Hjelte, Sweden

3830. Dworetzky, L. H., and Edwards, A., Principles of Doppler-inertial guidance, *ARS J.* **29,** 12, 967–972, Dec. 1959.

Inertial navigation systems are usually Schuler-tuned; this means that properly scaled integrated accelerometer signals are fed back to the gyro-stabilized accelerometer platform. A pure Schuler-tuned system is undamped, but damping can be introduced by internal feedback in the Schuler loop. This, however, causes velocity and acceleration-dependent errors in platform orientation and thus in computed Earth position and velocity of the vehicle. Authors show that errors can be reduced by adding velocity components from a Doppler radar to the Schuler loop.

Paper contains block diagrams for some alternative combined systems including a Doppler-inertial compass, and equations for computing the total errors resulting from gyro drift rate, accelerometer and Doppler velocity errors. Some optimal design aspects are discussed in general terms but no specific results are given. Bibliography includes many references (mostly confidential) dealing with Doppler-inertial navigation problems.

F. Y. Hjelte, Sweden

3831. Roberson, R. E., On guidance and control requirements in astronautics, *J. Franklin Inst.* **269,** 3, 196–220, Mar. 1960.

The question of what can be said about astronautical guidance and control requirements in general, without reference to specific missions, is explored. Mission characterizations are developed which give some broad indications of performance requirements trends. A "network" point of view toward trajectories is suggested which may have important implications to the establishment

of classes of functional requirements. Some general conclusions are reached about the qualitative degree to which requirement studies must be expected to be mission-oriented.

From author's summary

3832. Baranchuk, E. I., The theory of polydimensional tracking systems (in Russian), Trans. Second All-Soviet Conference on the Theory of Automatic Control, Vol. 1, Moscow-Leningrad, Akad. Nauk USSR, 1955, 501–520; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8419.

Some postulates of the theory of polydimensional tracking systems are developed on the basis of frequency analysis. The author introduces the conception of a matrix of the amplitude-phase, frequency characteristic, and demonstates that, if certain assumptions are fulfilled, the problem of analyzing the qualitative indices of polydimensional tracking systems can be reduced to the application of the known frequency methods of qualitative analysis. A derivation is given for an expression determining the mean square error of bi- and tri-dimensional tracking systems by the known parameters of the system and the input signal.

V. V. Solodovnikov

Courtesy Referativnyi Zhurnal, USSR

3833. Schuder, C. B., and Binder, R. C., The response of pneumatic transmission lines to step inputs, *ASME Trans.* **81** D (*J. Basic Engng.*), 4, 578–584, Dec. 1959.

Linearized equations for the transmission of pressure waves in a pneumatic line terminated with a volume are presented and solved. The Laplace transform and expansion formula are used to obtain the response to a step disturbance. The Hagan-Poiseuille law is used to represent the line resistance.

Authors neglect signal amplitude, heat transfer, and unsteady profile effects, so the solution is the same as for an electric transmission line with capacitance termination. Students using Weber ["Linear transient analysis," 1956, Vol. II] will recognize this to be Problem 8.12. The multiply reflected wave solution [Weber, Problem 8.13] has been presented by Pélissier [*Revue Gén. de l'Électricité* **59**, p. 395, 1950].

Small signal experiments performed by authors agreed with the solution. This would be expected from the agreement in their Ref. 6 for frequency-response analysis and testing.

R. L. Curl, USA

3834. The most important terms in automatic control (in various languages), *Elektrotech. u. Maschinenbau* **76**, 22, 553–556, Nov. 1959.

Tables, Charts, Dictionaries, etc.

Book—3835. Hyman, C., edited by, German-English mathematics dictionary, New York, Interlanguage Dictionaries Publishing Corp., 1960, 131 pp.

The present work is intended as a supplement to, and not as a substitute for, a general German-English dictionary. The student of German will note immediately that the nontechnical every-day translations of many terms have been excluded. On the other hand, every effort has been made to include all possible translations applicable in mathematics and related fields.

Another device employed to eliminate guesswork and mistranslation is the use of model phrases and sentences showing the application of a term in context.

Not counting subtitles, synonyms, etc., this dictionary contains more than 8500 entries, many of them not available either in large German-English dictionaries or in bilingual technical and scientific works.

From preface

Elasticity

(See also Revs. 3811, 3848, 3849, 3853, 3856, 3867, 3869, 3872, 3874, 3877, 3878, 3902, 3910, 3924, 3927, 3931, 3932, 3936, 3960, 3963, 3968, 3970, 3974, 3996)

3836. Mohan, M., Stresses due to a concentrated force in an infinite elastic parabolic plate not containing the focus, *Bull. Calcutta Math. Soc.* **51**, 2, 66–72, June 1959.

The force may act at any point of the plate, the parabolic boundary being stress free and the stresses and rotation vanishing at infinity. Muskhelishivili's method is applied in an orthodox manner. A check of results in the particular case where the force acts at the vertex of the parabola is provided by comparison with those derived from Tiffen's solution for a similar plate loaded on a finite arc, symmetric about the vertex, of the boundary [AMR **6** (1953), Rev. 3682].

P. Laasonen, Finland

3837. Graiff, F., General tensorial solution of indefinite equilibrium equation for a membrane (in Italian), *Atti Accad. Naz. Lincei, R.C. Cl. Sci. Fis. Mat. Nat.* (8) **26**, 2, 189–196, Feb. 1959.

The symmetric stress-tensor S_{ij} is expressed in terms of the metric tensor a_{ij}, the scalar curvature K, an arbitrary function ϕ and the derivatives of these quantities such that div $S_{ij} = 0$. The corresponding solutions are not made to satisfy any boundary conditions.

Apparently author is unaware of the work of Kondo and his school in Japan ["Basic problems in engineering sciences," I (1955); II (1958), Gakujutsu Bunken Fukyu-Kai, Tokyo].

B. R. Seth, India

3838. Kliachko, S. D., On the modeling of the first fundamental problem of the plane theory of elasticity for multiply connected regions, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23**, 2, 562–564, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

In general, solutions of title problems depend on value of Poisson's ratio. Since model material constants usually differ from those of actual body, Mossakovskii [AMR **9** (1956), Rev. 2132] proposed to conclude stress state from three models with different constants. Author shows that only two different models are needed to obtain solution by a certain kind of interpolation.

W. Mudrak, Austria

3839. Muller, R. A., The calculation of rock slips due to mining operations in horizontal and sloping strata (in Russian), Issled. po vopr. gorn. i marksheid. dela no. 31, 31–57, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9182.

Applying the equation of continuity of deformation as well as the relationship between the horizontal displacements of rock masses [cf. S. G. Avershin, "The displacement of rock strata in underground mining," Ugletekhizdat, 1947], author obtains a differential equation for the components of the vertical displacements, which coincides with the differential equation of heat conduction for a time-variable coefficient. The solution of the resulting equation is obtained by a Gaussian probability function and its derivatives for different working conditions at the face. An example is given for calculating the slip of the ground surface by this method.

I. V. Fedorov

Courtesy Referativnyi Zhurnal, USSR

3840. Seeger, A., and Mann, E., Application of nonlinear theory of elasticity to faults in crystals (in German), *Z. Naturforsch.* **14a**, 2, 154–164, Feb. 1959.

A third-order nonlinear theory of elasticity is used in calculating the displacement fields round a screw dislocation and an impurity atom in an isotropic continuum. Detailed comparisons are made with the standard infinitesimal theory, especially in the neighborhood of the fault.

R. Hill, England

3841. Kraus, H., and Sonnemann, G., Stresses in hollow cylinders due to asymmetrical heat generation, *ASME Trans.* **81** A (*J. Engng. Power*), 4, 449–454, Oct. 1959.

It is the goal of this investigation to determine the exact temperature distribution and the exact radial, axial, tangential and shear stress distributions produced in a long, hollow, circular cylinder with internal heat generation under steady-state conditions. The heat generation will be in the form of a decaying exponential in the radial direction and an arbitrary function of the angle round the longitudinal axis of the cylinder. There will be no variation along the axis of the cylinder.

It is assumed that the cylinder material is elastic, isotropic and homogeneous; that its properties remain independent of temperature; that conditions of plain strain apply; and that the arbitrary function of angle which describes the variation of internal heat generation . . . will be representable by an infinite series of sine terms . . . .

The solution of the problem is divided into two basic steps. First, the heat-conduction equation is solved to yield the temperature distribution in the hollow cylinder.

Second, a thermoelastic displacement potential is determined from the temperature distribution. All the stresses are obtained from this potential by taking appropriate combinations of its derivatives. Since it is found that the shear and radial stresses obtained in this manner do not vanish at the inner and outer surfaces of the cylinder, an Airy stress function from the ordinary theory of elasticity is superimposed on the displacement potential to cause the stresses to vanish as required.

From authors' summary by M. A. Jaswon, England

3842. Gatewood, B. E., Thermal stresses in moderately thick elastic plates, *ASME Trans.* **81** E (*J. Appl. Mech.*), 3, 432–436, Sept. 1959.

A three-dimensional analysis is made of thermal stresses in moderately thick elastic plates, with the approximation that σ_z (normal stress in thickness direction) and T (temperature) are polynomial functions of the co-ordinate z. Author then applies this to examine the errors involved in the generalized plane-stress approximation, i.e. where the stress components σ_z, τ_{xz}, τ_{yz} are taken to be zero and σ_x, σ_y, σ_{xy}, T depend only on x, y. He finds that σ_x, σ_y, σ_{xy} could be in error by about $70(h/a)^2 \cdot \alpha E \Lambda$ maximum; α stands for coefficient of thermal expansion, E for Young's modulus, Λ for maximum temperature gradient, h/a for ratio of plate thickness to plate dimension. On the other hand the error is not more than about $50(h/a)^3 \cdot \alpha E \Lambda$ for τ_{xz}, τ_{yz} and not more than about $360(h/a)^4 \cdot \alpha E \Lambda$ for σ_z. In view of the widespread use of generalized plane-stress conditions, these conclusions must be regarded as a valuable contribution to this field.

M. A. Jaswon, England

3843. Sneddon, I. N., and Lockett, F. J., On the steady state thermoelastic problem for the half-space and the thick plate, AFOSR TN 59-301 (Duke Univ.; ASTIA AD 213 085), 11 pp., Mar. 1959.

The problem of steady-state thermal stress is considered for a semi-infinite elastic body and an elastic solid bounded by two parallel planes $z = \pm d$, called a thick plate. All surfaces are free from traction but are under arbitrarily prescribed temperatures. Authors employ double Fourier transforms to obtain solutions in terms of two-dimensional Fourier integrals. The problem of the half space was studied previously by Sternberg and McDowell [AMR **10** (1957), Rev. 2055] by the method of Green with an important result that internal stress field is plane and parallel to the boundary. Present authors show that this result holds for the thick plate as well as the semi-infinite solid.

Solutions are presented for: (1) the half space whose surface temperature is uniform over a circular region and zero outside, and (2) the thick plate with a special temperature distribution on the upper face. Figures showing the difference of principal stresses are presented for both problems along with curves for the variation of the normal component of the displacement in planes parallel to the boundary for problem (1). For the thick-plate problem, the temperature distribution on the surface is chosen so that certain integrals appearing in the final solution can be easily evaluated.

D. Frederick, USA

3844. Hillier, M. J., Thermal stresses in reactor shells due to thermal neutron irradiation—Part I, *J. Nuclear Energy* **8**, 4, 187–196, Jan. 1959.

Capture of thermal neutrons in an iron slab produces γ-rays. These γ-rays are absorbed as heat; the heat generated can be found explicitly. The temperature distribution across the slab is calculated from the heat conduction equation and then the stress distribution from the thermoelastic equations. Author plots the maximum tensile stress for different external conditions.

Reviewer thinks that this approach could be used with cylindrical and polar spherical polar coordinates to find the stresses in cylindrical and spherical pressure vessels.

D. R. Bland, England

3845. Zadoyan, M. A., Temperature stresses in infinite concrete slabs with account taken of creep (in Russian), *Izv. Akad. Nauk ArmyanSSR, Fiz.-Mat. Nauk* **11**, 1, 27–46, 1958.

Transient thermal stress in infinite concrete slabs with account taken of creep has been investigated on the basis of Arutyunyan's theory of creep. The instantaneous modulus of deformation is assumed to be time dependent. The integral equations of creep are reduced to differential equations with initial conditions. Two illustrative examples concern (a) harmonic oscillation of temperature of the surrounding atmosphere, and (b) symmetric cooling of the faces. Numerical data show that creep halves the maximum thermoelastic stress in case (a), and changes the sign of stress in case (b).

J. Nowinski, USA

Courtesy Mathematical Reviews

3846. Katasonov, A. M., The propagation of spherical, thermoductile, elastic perturbations (in Russian), *Vestn. Mosk. In-ta, Ser. Mat., Mekh., Astron., Fiz., Khimii* no. 3, 39–49, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9159.

A medium is investigated, the stresses wherein are linear functions of the strains and rates of deformation. The propagation in such a medium of perturbations in an infinite space with a spherical cavity is studied. At the initial time instant, a pressure P is applied to the boundary of the cavity and the temperature changes instantaneously, thereafter remaining constant. By means of certain additional assumptions, the equations are resolved and the problem of determining the temperature field examined separately from the dynamic problem. The expression obtained for the temperature distribution is substituted in the dynamic equation which is then solved by operational calculus. The last section of the paper deals with a particular case of the problem, represented by an elastic medium on the assumption that $P \equiv 0$. In this case, at the post-initial time instant, there exist in the entire space stresses arising by the instantaneous transmission of the temperature to all points in the space (a linear law of heat conduction). In addition there is propagated from the cavity with the speed of sound, a longitudinal elastic wave, at the front of which the stresses experience finite discontinuities the magnitudes whereof decay in inverse ratio to the distance of the wave front from the center of symmetry.

S. S. Grigoryan

Courtesy Referativnyi Zhurnal, USSR

3847. McWithey, R. R., Minimum-weight analysis of symmetrical-multiweb-beam structures subjected to thermal stress, NASA TN D-104, 30 pp., Oct. 1959.

A minimum-weight analysis based upon buckling and yielding stresses is presented for multiweb beams subjected to thermal

stress. Curves of minimum structural weight and optimum values of the beam parameters are shown as a function of bending moment for various temperature differences between skin and web. Two examples are given of the use of the curves to obtain minimum-weight beams.

From author's summary by G. Gerard, USA

Viscoelasticity

(See also Revs. 3890, 3932, 3935, 3976, 3982, 2988)

3848. Barlow, A. J., and Lamb, J., The visco-elastic behavior of lubricating oils under cyclic shearing stress, *Proc. Roy. Soc. Lond.* (*A*) **253,** 1272, 52–69, Nov. 1959.

A theoretical and experimental investigation into the relaxation behavior of lubricating oils which are represented by spectra of Maxwell bodies. With very short transit times of the oil between load-bearing surfaces the effective dynamic viscosity of the lubricant will be less than expected from hydrodynamic considerations, while the load-bearing capacity will be greater. In a single relaxation time formulation, the shear stress is expressed as a linear function of the displacement gradient times a complex shear modulus. This leads to a definition of a static and a dynamic viscosity introducing a relaxation time representing "the time constant which governs the return to equilibrium of the system following a sudden disturbance."

Three oils were investigated. The experimental method employed to measure the shear mechanical impedance of the liquids at frequencies between 6 and 78 Mc/8 is based upon the measurement of the complex reflexion coefficient of an incident shear wave at a solid/liquid interface, the wave being polarized so that the shear displacement is parallel to the plane of interface. Following Alfrey [AMR **3** (1950), Rev. 2344] the experimental data are used for evaluating a distribution function of relaxation times. An attempt is made to correlate features of the frequency spectrum with various hydrocarbon types. It is shown that glass-like properties of a liquid at a temperature above the "normal" glass transition temperature may be observed by drastically reducing the time scale of the experiments. As little information is available on the shear elasticity of homogeneous organic liquids, this investigation breaks new ground. M. Reiner, Israel

3849. Olszak, W., and Perzyna, P., Variational theorems in general viscoelasticity (in English), *Ing.-Arch.* **28,** 246–250, Mar. 1959.

The object of the paper is to derive variational theorems for models of anisotropic rheological bodies taking the influence of temperature into account, the quantities undergoing variations being stresses and strains. Operational symbolism similar to that introduced by M. A. Biot is employed throughout. The notion of matrices is introduced, the elements of which are analytic functions of the differential operator p or the integral operator p^{-1}.

R. L. Bisplinghoff, USA

3850. Shorr, B. F., The effect of nonuniform heating on stress variation in creep, *Soviet Phys.-Doklady* **3,** 6, 1290–1293, June 1959. (Translation of *Dokladi Akad. Nauk SSSR* (*N.S*) **123,** 5, 809–812, Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

In manufacturing, under conditions of significant fabricating stresses, high mean temperatures, and large nonuniformities in the temperature field, a component will sometimes develop a state of creep which has abruptly varying rates at various points of the cross section, and which leads to a significant redistribution of the stresses as a function of time..... Hence in the design of components which are nonuniformly heated at high temperatures it is not sufficient to restrict the calculations only to the initial state of stress (even with thermal stress being taken into account); it is necessary to calculate the stress variation as a function of time.

From author's summary by M. A. Jaswon, England

3851. Oding, I. A., and Tulyakov, G. A., An investigation of the localization of plastic creep deformation under compound stress (in Russian), *Zavod. Lab.* **23,** 12, 1478–1480, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10622.

Creep tests were made at 600C, in plain torsion, plain tension, and combined torsion and tension, on a steel sample with a length of 100 mm. The strain distribution over the length of the sample was investigated.

The test results show that inhomogeneity of the strain distribution is particularly evident at strain values of the order of 0.3 – 0.4% and less. V. S. Namestnikov

Courtesy Referativnyi Zhurnal, USSR

3852. Gluck, J. V., Voorhees, H. R., and Freeman, J. W., Effect of prior creep on mechanical properties of aircraft structural metals, Part 1, WADC TR 57-150 (PB 131 716; ASTIA AD 150 956), 106 pp., Feb. 1958

Plasticity

(See also Revs. 3849, 3851, 3899, 3931, 3937, 3941, 3942, 3997)

Book—3853. Belyayev, N. M., Papers on the theory of elasticity and plasticity (in Russian), Moscow, Gostekhizdat, 1957, 632 pp. + illus. 16 r. 75 k; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10252.

This collection contains sixteen papers, arranged in chronological order of first publication; two of these are original publications. The papers are accompanied by commentaries. An extensive survey is included of the life and work of the author (1890–1944), including a review of his published works. This has been written by A. N. Mitinsky, A. N. Belyayev, N. Yu. Kushelev, A. V. Satalkin, and A. K. Sinitsky. The general editing of the work was in the hands of A. N. Mitinsky. The principal part of the collection consists of four papers on the theory of elastic contact, and six papers on the theory of plastic deformation. Also included are two papers on elastic rigidity, three on the mechanical properties of materials. An unfinished paper is included: "The motions of an aviator in an aircraft cabin at sudden cessation of the tractive force."

The book is, on the whole, of considerable value for scientific workers and those interested in the theories of elasticity and plasticity, both analytical and applied. N. A. Rostovtsev

Courtesy Referativnyi Zhurnal, USSR

3854. Kachanov, L. M., Variational methods of solution of plasticity problems, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 3, 880–883, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Author considers elastoplastic problem of a strain-hardening body. He proposes a method of successive approximations for displacements and stresses in a form somewhat akin to the iterative solution of integral equations. The method is based on deformation theory and apparently makes the implicit assumption that no unloading occurs. Displacements are determined by minimizing successive approximations to the virtual work, and stresses are determined by minimizing the complementary energy. The elastic solution is proposed for the zero-order approximation. No discussion of convergence nor of the rate of convergence is given, nor are any sample problems solved. Reviewer suspects that convergence will be slow in most cases.

J. M. Frankland, USA

3855. Pogodin-Alekseev, G. I. and Vasil'eva, A. G., On methods of determining the localized and uniform plasticity in tension, *Indust. Lab.* **24,** 11, 1523–1525, Nov. 1958. (Translation of *Zavod. Lab., USSR* **24,** 11, 1394–1395, Dec. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

3856. Unksov, E. P., and Zavartseva, V. M., The use of the optical polarization method for strain analysis in plastic swaging (in Russian), Vopr. konstrukts. prochnosti stali, Moscow, Mashgiz, 1957, 228–254; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9154.

The elastic stress condition approaching the (yield) limit after which plastic (strain) deformation immediately commences is investigated on optically active models. It is assumed that the onset of plastic strain deformation and the first reductions of area with the development of slight plastic flow are defined by the limiting elastic state. The stress distribution is investigated in the forging of circular shafts on flat and profiled hammer dies, as well as of rectangular forgings in flat die falls.

V. P. Netrebko
Courtesy Referativnyi Zhurnal, USSR

3857. Karpov, G. I., Strain inhomogeneity in plastic compression, Pt. 1 (in Russian), *Fiz. Metallov i Metallovedeniye* **2,** 1, 168–171, 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9333.

An investigation of the change in mechanical properties of copper at different levels of the cross section of a sample tested in compression. The test pieces were preliminarily compressed to 34.6% at a rate of 3 mm/min, then machined to a cylindrical shape, and again compressed by stages. The diameter of the different cross sections, over the height of the sample, were then measured microscopically. The deformation in each cross section after second compression was then determined by the magnitude of the relative change of area. From these data and the loading values, flow curves were calculated for each section. In accordance with known data, it was found that the strain in the compression of cylindrical samples is inhomogeneous over the height of the sample, the properties of the cold-worked metal varying similarly. The variation in strain along the radii of the cross sections was not investigated.

P. O. Pashkov
Courtesy Referativnyi Zhurnal, USSR

3858. van Rooyen, G. T., and Backofen, W. A., Distribution of interface stress in plane strain and axial symmetric compression, *J. Mech. Phys. Solids* **7,** 3, 163–168, June 1959.

Authors give interesting experimental results obtained with pressure-sensitive pin technique (previously described) on lead (nonhardening metal), comparing two cases: plane strain in compression and axial symmetric compression. The agreement is good.

They also compare experimental results with theory developed by Hill for such case. A disagreement is found only in a region near the edges of the specimen. Reviewer feels that discussion should be continued, for instance, to check out, in more detail, up to what extent the theoretical hypotheses are fulfilled in experiments.

For the engineer the results are interesting because they give confidence in the theory of plasticity and can be applied to practical cases; for instance, to the compression test.

J. A. Cintra, Brazil

3859. Razov, I. A. and Shevandin, A. M., The effect of loading speed and testing temperature upon the limiting plasticity of steel, *Indust. Lab.* **25,** 2, 209–213, Mar. 1960. (Translation of *Zavod. Lab., USSR* **25,** 2, 198–201, Feb. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

3860. Freiberger, W., Minimum weight design of cylindrical shells, *J. Appl. Mech.* **23,** 4, 576–580, Dec. 1956.

Problem is to determine the wall thickness $b(x)$ of a circular cylindrical shell under constant axial tension and arbitrary internal pressure $p(x)$ within minimum weight design. Loading and support are axisymmetrical. For shells made of plastic-rigid material that obeys Tresca yield criteria and associated flow rule, Onat [AMR **8** (1955), Rev. 3736] has developed a yield surface S for stress resultants N_x, N_φ, M_x. For minimum weight design the point representing critical combinations of N_x, N_φ, M_x must move on certain edges of S [Onat & Prager, *Ingenieur* **67,** 46–49, 1955].

Equilibrium equations coupled with above conditions give a differential equation for $b(x)$. Author indicates its general solution in case where the shell is supported at both ends by inextensible rings and M_x changes sign at x_1 and x_2. Expressions for $b(x)$ involve quotients of trigonometric and hyperbolic functions and integrals of the type

$$\int^{x} p(t) \sin k(x-t)\, dt.$$

Two additional equalities with similar terms give implicitly x_1 and x_2.

For the particular case where p is constant over the interval $a \leq x \leq b$ and zero elsewhere the solution is worked out and an example is shown. This is also done for the case of a linearly decreasing pressure which decreases to zero at one end.

G. H. Beguin, Switzerland

3861. En-Rip, B., Rigid plastic analysis of membranes taking account of strain-hardening (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 101–103, June 1958.

This short note treats rigid-plastic, clamped circular membranes of initial radius r_0 and thickness h_0 under uniform pressure p bulging to form a spherical surface with uniform thickness. The Tresca yield condition and the flow law $\sigma_r = \sigma_0 + C(\varepsilon_r + \alpha\varepsilon_\theta)$, $\sigma_\theta = \sigma_0 + C(\alpha\varepsilon_r + \varepsilon_\theta)$, where σ_0 is the yield stress, C the plastic modulus, α a constant, were assumed after Hodge's generalization [*J. Appl. Mech.* **24,** 3, p. 483, 1957] of Prager's suggestion [*J. Appl. Mech.* **23,** no. 4, 1956] to get $p^* = ap/\sigma_0 h_0 = 4(1 - C(\alpha + 1) \log \cos \theta/2) \sin \theta/2 \cos^3 \theta/2$, where θ is the half central angle of the deformed spherical surface. Calculated results were compared with those by Hill and others to show the significance of the assumed flow law, especially of α.

M. Kuranishi, Japan

3862. Iagn, Iu. I., and Shishmarev, O. A., Study of the plastic strain in thin-walled metal tubes under combined tension and torsion, *Indust. Lab.* **24,** 10, 1373–1375, Nov. 1959. (Translation of *Zavod Lab., USSR* **24,** 10, 1243–1244, Oct. 1958 by Instrument Society of America, Pittsburgh 22, Pa.

3863. Bland, D. R., The generalized plane strain of an elastoplastic material (in English) *ZAMP* **10,** 2, 113–133, Mar. 1959.

Assuming that the stress normal to the plane of the generalized plane-strain is the intermediate principal stress and using Tresca's yield criterion, author discusses two methods of solution: one for nonhardening materials, the other for linearly work-hardening.

The equilibrium and yield equations are hyperbolic for a nonhardening material. The derived equations, referred to the characteristics, differ from those for the rigid-plastic material only through the presence of additional terms in the Geiringer equations.

For a work-hardening material it is assumed that strains are small and rotations of the principal axes of stress are negligible. The derived equations are elliptic. Hence, a stress function is introduced satisfying a nonlinear partial differential equation of the fourth order. Solutions for several simple problems, reducible to ordinary differential equations, are discussed. However, the general procedure for solution of particular problems has yet to be formulated.

The influence of temperature is also considered.

R. Schmidt, USA

3864. Titov, V. K., and Lagutin, V. P., On errors in determining the residual stresses in hardened gray cast iron by the mechanical method, *Indust. Lab.* **25,** 1, 106–108, Mar. 1960. (Translation of *Zavod. Lab., USSR* **25,** 1, 99–100, Jan. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

3865. Sevast'yanov, V. Ya., A method of measuring the thickness of the removed layers and deformations of a flat specimen in calculating the residual stresses, *Indust. Lab.* **25,** 2, 213–215, Mar. 1960. (Translation of *Zavod. Lab., USSR* **25,** 2, 202–203, Feb. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

3866. Lutzau, W. H., and Rowinski, B. M., The plotting of relaxation curves from reserve x-ray photographs at high temperatures (in Russian), *Zavod. Lab.* **23,** 8, 962–963, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9374.

An installation is described for obtaining relaxation curves by the measurement of the lattice strains, and the results of experiments with copper and aluminum are presented. It is observed that comparison of the results obtained by the method described with those obtained by measuring the transverse deformation of the sample enable the details of the relaxation process to be disclosed.

I. M. Gryaznov

Courtesy Referativnyi Zhurnal, USSR

3867. Rozenblyum, V. I., On shakedown of nonuniformly heated elastoplastic bodies (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 136–138, July 1957.

Assuming the temperature distribution in a form $\theta(x, y, z, t) = g(t) + \rho(t)\,\Phi(x, y, z)$ where $g(t)$ and $\rho(t)$ are any functions of time, $g(t)$ having no effect on the residual stress and $0 < \rho(t) < \rho_1$, this short note suggests that the shakedown load corresponds to the maximum, purely elastic thermal shear stress $\rho_1 \sigma_{1\,max}$ calculated from $\rho_1\,\Phi(x, y, z)$ equal to twice the yield shear stress σ_S, and if $-\rho_0 \le \rho(t) \le \rho_1$, and $\rho_0 \le \rho_1$, $\rho_1\,\sigma_{1\,max} = 2\sigma_S\rho_1/(\rho_0 + \rho_1)$.

M. Kuranishi, Japan

Rods, Beams and Strings

(See also Revs. 3797, 3892, 3894, 3906, 3911, 3912, 3915, 3922, 3924, 3953, 3994, 3997)

3868. Muller, L. S., Bending moments on interconnected beams, *Concrete Constr. Engng.* **54,** 10, 325–335, Oct. 1959.

An approximate method is given for the calculation of maximum bending moments on interconnected beams freely supported at their ends or continuous in a single direction. The torsional restraint of one beam on another is neglected and it is assumed that the deflections of the central cross beams are equal. It follows that the ratio of the maximum bending moment in one intermediate beam to the bending moment in the parallel central beam is equal to that of the corresponding deflections.

Paper includes two tables and four nomograms, very useful for the determination of the proportionality coefficients of the partial loads for each beam; method is also illustrated by two numerical examples.

Reviewer believes it would have been useful to estimate the order of magnitude of the errors with respect to the rigorous method.

M. V. Soare, Roumania

3869. Gliavin, Yu. V., The problem of the analysis of beams of complex form by the hypothesis of cylindrical sections (in Russian), *Trudi Gor'kovsk. Politekhn. In-ta* **13,** 4, 101–104, 1958; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9208.

A transformation is performed of the coefficients of the expressions for determining the stresses in a flat strip with cutouts and projections, in tension and bending. [cf. A. V. Verkhovskii, *Trudi Gor'kivsk. Politekhn. In-ta,* **9,** (1951)].

The results are correct only for cutouts and projections with an outline which is a circular arc. This is not mentioned in the paper.

K. V. Solyanik-Krassa

Courtesy Referativnyi Zhurnal, USSR

3870. Kobets, L. G., The fundamental equations of the stress-strain state of elastic, open, thin-walled beam sections at large torsional angles (in Russian), *Trudi Kharkovsk. Inzh.-Stroit. In-ta* no. 5, 99–110, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10478.

The problem is examined of the torsional bending of straight, thin-walled, elastic beams of open cross section with a constant profile at large angles of displacement with reference to the longitudinal axis. The angular displacements with reference to the axes in the plane of the cross section, as well as the elongations and shears, are assumed to be small. Use is made of the equations of the nonlinear theory of the distortion of thin shells. Equations are derived for the generalized forces corresponding to the seven generalized dipslacements of the cross section of a thin-walled beam.

K. F. Kovalov

Courtesy Referativnyi Zhurnal, USSR

3871. Khlebutin, N. V., The analysis of thin-walled supported beams of open cross section (in Russian), *Trudi Kharkovsk. Aviats. In-ta* no. 17, 225–246, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10481.

The problem of the compound strength of a beam is investigated by the method of Yu. G. Odinokov [*Kazansk. Aviats. In-ta,* no. 18, *Trudi* 1946]. The calculated system is represented by a thin-walled beam of constant open cross section consisting of longitudinal stringers with connecting panels. It is assumed that the stringers work only in tension, and the panels only in shear. A solution and analysis are presented of the equations set up by Odinokov for the stresses and displacements in such a beam. These are compared with the solution of the problem presented by V. Z. Vlassov ["Thin-walled elastic beams", Gosstroyizdat, 1940], which does not consider the shearing strains in the median plane of the beam. It is demonstrated that the solution of Vlassov can be superimposed by a self-balancing system of stresses or corresponding displacements.

Yu. D. Kopeikin

Courtesy Referativnyi Zhurnal, USSR

3872. Milne-Thomson, L. M., Flexure, *Trans. Amer. Math. Soc.* **90,** 1, 143–160, Jan. 1959.

In the conventional formulation of the flexure problem for a beam [e.g., I. S. Sokolnikoff, "Mathematical theory of elasticity," 2nd. ed., McGraw-Hill, New York-Toronto-London, 1956], the two non-vanishing shear stresses are obtained in terms of derivatives of a harmonic function f: $\tau_{13} = \partial f/\partial y$ + other terms; $\tau_{23} = -\partial f/\partial x$ + other terms; where these other terms can be written down explicitly. It follows that the complex combination $\tau_{31} - i\tau_{32}$ involves

$$\frac{\partial f}{\partial y} + i\frac{\partial f}{\partial x} = -\frac{\partial g}{\partial x} + i\frac{\partial f}{\partial x} = i\frac{d}{dz}(f + ig),$$

where g is complex conjugate to f; consequently the complex shear stress is expressible in terms of an analytic function. Milne-Thomson obtains this result from first principles, and uses it in conjunction with conformal mapping into a unit circle to obtain the solution for flexure of a circle, cardioid, and lemniscate. Similar but less compact mapping methods are given by Sokolnikoff [loc. cit., p. 219].

C. E. Pearson, USA

Courtesy Mathematical Reviews

3873. Simvoulidi, I. A., Equations for the analysis of elastically-supported beams (in Russian), *Sb. Trudi Vses. Zaochn.*

Inzh.-Stroit. In-ta **1**, 72–77, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10470.

Expressions are developed for calculating beams transmitting the load to a continuous elastic and isotropic medium, characterized by a constant value of the modulus of elasticity and Poisson's ratio. The reactive pressures of the supports on the beam are approximated by a fourth-order polynomial. The settling of the foundations (supports) is dealt with by the well-known Flamand formula. The expressions finally derived are not particularly simple, and no concrete examples of their application are given.

P. I. Klubin

Courtesy Referativnyi Zhurnal, USSR

3874. Ikeda, K., and Sunakawa, M., The stress distribution in a sweptback box-beam under torsional and bending loads, Aero. Res. Inst., Tokyo University, Rep. 347, 149–159, July 1959.

A method of analysis for a sweptback box beam is presented, employing the self-equilibrating force procedure utilizing shear flows. Using a variation of the energy method, a sample structure is investigated for several types of loads. The well-known Spar behavior at the root is revealed.

H. Becker, USA

3875. Garcia Ortega, M., Design of reinforced concrete sections, Parts I and II (in Spanish), Inst. Techn. Constr. Cem. Publ. 187, 195 pp., 1959.

Sections considered are rectangular, T, and circular. Study includes mild and high-strength reinforcement. Two stress-strain curves of concrete are studied: straight line up to failure and second-degree parabola with vertex at maximum stress, neglecting descending branch of the curve. Part I develops analytical expressions for computing pertinent parameters under pure flexure and combined flexure and compression. Part 2 gives extensive tables and charts based on expressions of first part. No comparison with test results is included.

E. Rosenblueth, Mexico

Plates, Shells and Membranes

(See also Revs. 3837, 3843, 3860, 3861, 3869, 3892, 3901, 3902, 3903, 3910, 3916, 3962, 3970, 4162, 4290)

3876. Bergmann, L., Experiments with vibrating soap membranes (in German), *Akustische Beihefte* no. 1, 185–190, 1959.

The method of making visible vibration maximum fringes in soap membranes, already published by the author [AMR **10**(1957), Rev. 2430], is described and illustrated by some new examples, e.g. of a membrane having the contours of a violin back. Reviewer doubts if the latter experiment is of practical interest, because a violin performs flexural and not membrane vibrations. Nevertheless, the new examples show once more the astonishing efficiency of a relatively simple method for making excellent photos of membrane vibrations.

E. Monch, Germany

3877. Bassali, W. A., The transverse flexure of uniformly loaded and fully restrained thin isotropic plates with curvilinear edges, *J. Mech. Phys. Solids* **7**, 3, 145–156, June 1959.

With the assumption of the small-deflection theory of thin isotropic plates, solutions in finite terms have been obtained for the complex potentials and deflections at any point of a clamped and uniformly loaded plate, taken in the z-plane, that can be mapped on the unit circle γ in the ρ-plane by the function

$$z = c\,\rho/(1 + m\,\rho^n)$$

where $n \geqslant 2$ and $-1 \leqslant m(n-1) \leqslant 1$.

As special cases, the plate becomes bounded by approximately circular arcs for $m = -2/[n(n-1)]$; while the plate corresponding to $n = 2$ has the form of the inverse of an ellipse with respect to its center. In the latter case the expression of the deflection tallies with that obtained by Sen [*Phil. Mag.* **33**, p. 294, 1942].

S. C. Das, India

3878. Lakshminarayana, G., Finite bending of plates, *J. Sci. Engng. Res., India* **3**, 1, 130–144, Jan. 1959.

Following the method of B. F. Seth [*ZAMM* **37**, 393–398, 1957] the author treats the following problems: (A) a cylindrically aelotropic plate is bent into a right cylindrical shell by edge moments and forces; (B) the same problem for a two-layer composite plate; (C) a two-layer composite plate is bent into the form of a spherical shell by edge forces and moments. Second-order terms in the strains are retained. It is shown that bending of the type described in A, B, C is possible. Expressions are found in closed form for resultant ments and shears required to do this. A number of numerical examples are worked, but since the results are not stated in dimensionless form and since the units employed are not stated, reviewer feels that the computations are less useful than they would otherwise be. No comparison is made with the predictions of elementary plate theory.

L. E. Goodman, USA

3879. Parsons, H. W., and Leggett, D. M. A., The small deflection of a normally loaded square plate, elastically supported along its edges (in English), *Acad. Serbe Sci., Publ. Inst. Math.* **12**, 1–10, 1958.

Authors study uniform pressure on an infinite uniform plate reinforced by a square mesh of uniform beams and supported at their intersections. Making the usual simplifying assumptions and using energy principles, they determine the important deflections and bending moments.

L. H. Donnell, USA

Courtesy Mathematical Reviews

3880. Shavishmelashvili, V. N., The analysis of a rectangular slab by the method of strips (in Georgian), *Trudi In-ta Stroit. dela Nauk Akad. GruzSSR* **6**, 35–49, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10298.

Analysis of the slab is performed by the straight-line method [cf. L. V. Kantorovich, *Izv. Akad. Nauk SSSR* no. 5, 1955; M. G. Slobodyansky, *Prikl. Mat. Mekh.* **7**, no. 1, 1939]. This method enables the biharmonic equation of the problem to be reduced to a system of ordinary differential equations. These are solved, for the case of a slab with the ends of the strips hinge-supported and the other sides arbitrarily constrained, by Fourier expansions; in the case of arbitrary (indeterminate) boundary conditions at the ends of the strips, the variational method is applied. The problem of an orthotropic slab with hinge-supported strip ends is discussed.

P. M. Barvak

Courtesy Referativnyi Zhurnal, USSR

3881. Ventskovsky, B. K., The bending of a circular flat plate under simultaneous transverse and radial loading (in Russian), *Nauchn. Trudi Moskovsk. Poligr. In-ta* no. 5/6, 109–124, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10301.

An investigation of the bending of thin circular plates acted upon simultaneously by a transverse axially-symmetrical load and radial forces uniformly distributed over the periphery. The solution is obtained as a particular case of the analagous problem of an annular plate by a transformation at the limit. The equations are set up in the form characteristic of the method of original parameters. The influencing functions, representing a combination of cylindrical functions, are tabulated. A numerical example is discussed.

S. N. Sokolov

Courtesy Referativnyi Zhurnal, USSR

3882. Fleischmann, N. P., The elastic equilibrium of a slab with stiffening ribs of varying curvature (in Ukrainian), *Nauk. Zap.*

L'vovsk. In-ta **44,** 5–16, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10296.

A solution is presented for the bending deflection of a thin plate having a number of openings stiffened by ribs in the form of closed rings. The stiffeners are regarded as thin elastic rings with constant rigidity in bending and torsion, the stress condition whereof is sufficiently described by the theory of infinitesimal deflection of slender curvilinear rods. The problem of the bending deflection of such a multiply-linked system is reduced to the solution of a system of boundary equations for the Kolossov-Muskhelishvili functions, $\varphi_k(z)$ and $\Psi_k(z)$ $(k = 0,1,2,\ldots)$.

D. V. Vainberg
Courtesy Referativnyi Zhurnal, USSR

3883. Tschech, E., Membrane stresses in conical shells (in German), *Öst. Ing.-Arch.* **13,** 1, 23–27, May 1959.

Formulas for membrane stress resultants in conical shells referred to any orthogonal curvilinear coordinates are derived. The same formulas were derived by A. L. Gol'denveiser in his book: "Theory of elastic, thin shells" [Moscow, 1953, p. 126; AMR **9** (1956), Rev. 2876].

Obtained formulas are applied to calculation of membrane stresses in a circular, oblique, conical shell loaded by uniform internal pressure. A. Kornecki, Israel

3884. Chinn, J., Cylindrical shell analysis simplified by beam method, *J. Amer. Concr. Inst.* **30,** 11, 1183–1192, May 1959.

After briefly explaining "beam method" of analyzing cylindrical shells, author presents formulas he had developed for second step of that method, concerning arch calculation of the shells without edge beams, first step being the classical beam calculation. Assumptions involved and corresponding limitations are mentioned, enabling author's statement that his approach can be used with sufficient accuracy in many practical cases under all conditions of support. A numerical example is given, showing good agreement with results obtained by using ASCE Manual no. 31, "Design of cylindrical concrete shell roofs."

F. Correia de Araújo, Portugal

3885. Bongard, W., Theory and calculation of shells having the shape of an equilateral hyperbolic paraboloid (in German), Bautech.-Arch. no. 15, 44 pp., 1959.

The objective of this paper is to establish the general equations of a hyperbolic paraboloidal shell with equal sides, whose equation is $z = xy/a$. The analysis is based on vectorial calculus and tensorial notation is completely avoided. After a short review of differential geometry, the equilibrium equations of the complete bending theory are set up by using the asymptotes of the surface as (oblique) coordinate lines. Then the (σ, ε) relations as well as the relations between the deformation tensor and the displacement vector (u, v, w) are established in this system of coordinates. Finally, the force and moment resultants $(N_x, N_y, N_{xy}; M_x, M_y, M_{xy}, M_{yx})$ are expressed in terms of the displacements u, v, w, of the middle surface. The expressions obtained are very complicated and not suitable for numerical applications. They are then expanded in power series of x/a and y/a, which gives simplified expressions of these resultants. The booklet closes without any application of the general or simplified equations.

C. E. Massonnet, Belgium

3886. Soare, M., About the membrane theory of conoidal shells (in German), *Bauingenieur* **33,** 7, 256–265, July 1958.

Symmetric surface $z = x \cdot f(y)$, $f(y) = f(-y)$, over rectangular ground plan. General integration of the equations of equilibrum for distributed load, especially own weight and hydrostatic pressure. In case $f(y)$ is a parabola, semicircle or catenary finished formulas are given. H. Schaefer, Germany

3887. Oravas, G.-A., Analysis of thin elastic shallow segmental shells (in English), *Publ. Int. Assn. Bridge Struct. Engng.* **18,** 201–214, 1958.

A method of stress analysis is presented for shells that are segments of rotational surfaces generated by shallow segments of second-degree curves. Analysis is based on previous paper by author on spherical calotte shells [AMR **12**(1959), Rev. 684]. Present analysis applies to shells which have two intersecting meridional edges and one parallel edge, and are subject to uniformly distributed normal load and uniform temperature increment. Two sets of boundary conditions are considered: simply supported on all three edges, and simply supported on meridional edges but free on parallel edge. Solution is expressed in terms of trigonometric series coupled with Kelvin functions. Solution is limited to segmental shells spanning circumferential angles θ which conform to the restriction π/θ = integer. A numerical example is given.

D. O. Brush, USA

3888. Movsisyan, L. A., Some specific properties of anisotropic shells (in Russian), *Izv. Akad. Nauk ArmyanSSR, Fiz.-Mat. Nauk* **11,** 4, 137–144, 1958.

Membrane states of stress in cylindrical, conical and spherical shells with fairly general anisotropy, the only plane of elastic symmetry being tangent to the middle surface of the shell, are considered. Trivial calculations show that, e.g., (a) a cantilever circular cylindrical shell suffers a twist if acted on by a uniformly distributed load, the reversed load producing a reversed twist, (b) torsion of the shell (a) produces a radial displacement and a longitudinal stress with the rule of reversibility still valid, (c) hemispherical shell does not retain its spherical shape under the action of a uniform load, etc. J. Nowinski, USA
Courtesy Mathematical Reviews

3889. Immerman, A. G., Determination of the lower limit of critical stress in a circularly-cylindrical shell under axial compression (in Russian), Researches: steel structures, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 5–18, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10286.

A lower limit is established for the critical stress in a circular-cylindrical shell under axial compression. The starting conditions are represented by the equations of stability suggested by S. A. Alexandrovsky for the case of pure axial compression ["Analysis of three-dimensional structures", no. 3, Moscow, Gos. izd-vo lit. po str-vu i arkhitekture, 1955]. Author introduces the assumption that for a given ratio of the half-wavelength in the direction of the circumference to the half-wavelength along the generatrix, $n^2\mu$ = const, where n = number of waves along the circumference when stability is lost; $\mu = t/R$ = relative thickness of the shell. The lower limit of critical stress in pure compression is found to be equal to $p = 0.247\,E\mu$. This value is considerably higher than those found by Kempner [*J. Aero. Sci.* **21,** 5, 329–335, 342, 1954], $(p = 0.195E\mu)$, and Karman and Tsien [*J. Aero. Sci.* no. 8, 1941], for cylindrical shells. F. S. Isanbaeva
Courtesy Referativnyi Zhurnal, USSR

3890. Grigoryan, G. S., The calculation of inertialess thin shells of reinforced concrete of arbitrary outline with allowance for creep of the concrete (in Armenian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-Mat. Nauk* **10,** 4, 67–81, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10391.

The problem is investigated of the redistribution of forces between the concrete and the reinforcement in thin inertialess shells owing to creep of the concrete, founded on the creep theory developed by N. Kh. Arutyunian ["Some problems of the theory of creep," 1952]. The problem is reduced to the integration of two discrete ordinary differential equations of the second order with interchangeable coefficients, depending on time and on specific

parameters characterizing the creep of the concrete and the percentage of reinforcement. From the solution of these equations it is possible to obtain expressions for the stresses in the concrete and the steel, in the following form:

$$\sigma_{conc} = \sigma^{\circ}_{conc} - H_{conc}\,\sigma_{reinf} = \sigma^{\circ}_{reinf}\,H_{reinf}$$

where σ°_{conc}, σ°_{reinf} are the stresses in the concrete and the reinforcement respectively, neglecting creep; H_{conc}, H_{reinf} are coefficients representing the influence of creep of the concrete. The values of the coefficients H_{conc} and H_{reinf} are presented in the form of tables for spherical and parabolic shells loaded by their own weight.

K. T. Khachaturyan

Courtesy Referativnyi Zhurnal, USSR

3891. Hangan, M., and Soare, M., Shortened computation of cylindrical containers (in French), *Ann. Inst. Tech. Bât. Trav. Publics* **12**, 135/136, 261-279, Mar./Apr. 1959.

The usual formulas for stress analysis of cylindrical containers refer only to the extreme cases where the lower edge of the wall is either built into an absolutely rigid foundation, or free rotating. Really, the wall is continuously connected to the bottom slab; thus, the lower edge of the wall is elastically clamped. Because of this the interaction between wall and slab must be taken into account. This problem is solved in paper using the exact theory of shell flexure. The unknowns of problem are the bending moment and shearing force uniformly distributed along the lower edge of wall. A brief account of the theory, several graphs for the practical stress analysis and a numerical example complete the study.

J. Barta, Hungary

Buckling

(See also Revs. 3847, 3942)

Book—3892. Umanskogo, A. A., Analysis of spatial structures, Vol. 4 [Raschet prostranstvennykh konstruktsii], Moscow, Gosudarstvennoe Izdatel'stvo Literatury po Stroitel'stvu, Arkhitekture i Stroitel'nym Materialam, 1958, 554 pp. 26r.

Book consists of a collection of 21 original papers dealing with the equilibrium and stability of beams, rings, frames, plates, and shells.

The first paper, "Stability of slightly distorted and externally loaded I-beams" by B. M. Broude, treats the equilibrium of simply supported I-beams whose webs are curved rather than plane. Linear theory is employed to treat concentrated transverse loads as well as the case of end ements. Tables are presented to account for the effects of various degrees of initial curvature. The second paper, "An experimental investigation of the stability in plane deformation of an I-beam beyond the elastic limit" by G. M. Chubikin, presents the results of tests of a number of beams subjected to pure bending. The next paper, "Stability of rotating columns in tower-type cranes" by I. Y. Kogan, treats the problem of stability of a column braced at intermediate supports and subjected to a load at its upper extremity, the direction of the load changing with increased deflection. The fourth paper, "Stability of framed domes" by M. Y. Borodynskii, develops tabular methods for investigating the end-displacements as well as end-rotations of the various bars in a dome-shaped spatial structure. Stability of such structures is investigated on the basis of linear theory.

The fifth paper, "Effect of the core of a wall frame on a multistory building subject to wind load" by B. A. Dzarzhyunskii, treats, by linear theory, the warping of the various elevations of a tall building subject to horizontal wind load. The stiffening effect of fillers in wall cut-outs is considered. The analysis of the general strength of the body of all-metal cars is discussed by V. A. Mar'in in the sixth paper. A long railway car is treated as a beam of variable rigidity by linear theory. The seventh paper, "Matrix method of analysis of regular systems of bars" by V. D. Shaikovich, develops in elegant fashion a matrix method of analysis of frames and multi-story buildings that would be of considerable value to the civil engineer. The matrix manipulations are presented in such a torm as to require a minimum of numerical calculation. The analysis of circular wheels is discussed in the eighth paper by M. K. Frusov. The small-deflection theory of curved beams is employed and the resulting equations solved for various bending and twisting loads on the ring. "Certain problems in the static and dynamic analysis of regular systems" is the topic of the ninth paper, by V. N. Kutukov. Natural frequencies of lumped-mass systems are determined in rather routine fashion. Finite-difference methods are employed in the usual fashion to investigate vibrations of plates. The tenth paper, "Statics of thin-walled bars composed of arms joined in a plane" by R. M. Rappoport, considers various loadings on a member composed of two structural channels joined by flat plates extending over the flanges. The elements are all assumed to be thin-walled and approximate expressions for rigidities are employed.

The eleventh paper, "Analysis of girderless ceilings" by A. S. Kalmanok, utilizes linearized plate theory to study stresses in a uniformly loaded ceiling supported by equally spaced columns. Rapidly converging series solutions are presented for deformations and accompanying stresses. The next paper, "Approximate method of analysis of the strength of a closed cylindrical shell with constant transverse cross section" by V. V. Novitskii, treats the membrane behavior of a closed shell of arbitrary cross section, constant along its length. The analysis follows the conventional approach for such a problem, except that warping of the cross sections is considered. The next paper, "Analysis of oblique concial shells" by V. V. Novitskii, is restricted to the membrane analysis of such a shell. The governing differential equations for small deflections are solved by an ingenious separation of variables technique. The fourteenth paper, "Integration of the equations of axisymmetrically loaded shells of revolution" by Y. F. Khlebnoi, considers the bending deformations of shells of linearly varying thickness of cylindrical, conical, or spherical shape. Deflections are expressed as the products of harmonic functions and exponentials, which appears to offer some advantage, particularly in regard to presenting a unified treatment for all of these geometries, over the usual methods of analysis. The fifteenth paper, "Analysis of shallow shells of revolution with rectangular base projections" by V. V. Dikovich, utilizes the linearized Vlassov equations for shallow shells. The equations are solved in rather conventional fashion by assuming solutions in harmonic series.

The analysis of slightly curved rectangular plates as shallow shells of double curvature is next discussed by A. S. Kalmanok. The linearized Vlassov equations are employed and solved by complex variable techniques for the case of a plate with rectangular boundaries. Maximum deflections as well as stress resultants are tabulated for a range of initial curvatures of the plate. A survey of investigations in the theory of bending of plates and shells during the period 1941 to 1957 is developed by A. S. Vol'mir. Emphasis is on nonlinear effects and buckling problems. The survey is quite comprehensive and includes references to 174 papers, many from the Western literature. The "Stability of reinforced circular cylindrical shells subject to compression and pure bending" is investigated by K. D. Trukin. Linearized theory is employed and results are shown to be in good agreement with tests conducted on twelve cylindrical shells.

The stability of orthotropic cylindrical shells subject to axial compression is discussed by O. N. Len'ko on the basis of finite deflection analysis. The principle of minimum potential energy is employed and load-deflection relations established. Unfortunately no comparison is offered with a recent paper by March and Kuenzi [AMR **6**(1953), Rev. 811]. The next paper is "Loss of stability of a circular cylindrical shell subject to the combined action of longi-

tudinal and transverse loads" by A. G. Immerman. Linearized theory is employed to refine the analysis due to Windenburg and Trilling, *Trans. ASME* 1934. The book concludes with a consideration of the carrying capacity of circular cylindrical panels reinforced by ribs, by O. I. Teribushko. The panels are assumed to be reinforced by widely spaced stringers in the direction of a generator, as well as circumferentially. Finite-deflection theory together with the principle of minimum potential energy is employed to predict load-deflection characteristics.

W. A. Nash, USA

3893. Galambos, T. V., and Ketter, R. L., Columns under combined bending and thrust, *Proc. Amer. Soc. Civ. Engrs.* **85,** EM 2, (*J. Engng. Mech. Div.*), 1–30, Apr. 1959.

The analysis is presented to determine the ultimate carrying capacity of a pin-ended wide flange steel beam-column, subjected to axial thrust and bending moments. Two loading cases are investigated: axial thrust combined with equal end moments and axial thrust with moment applied at one end only. In both cases it is considered that the material is ideally elastoplastic and it is assumed that the plane of the applied moments is that of the web of the section and that failure is the result of excessive bending in this same plane. The influence of an assumed symmetrical residual stress pattern is considered in the calculations.

For the solution of the problem, configuration of deflection is assumed, as well as nonlinearity between moment and curvature as the stress exceeds the initial yield strain.

Moment-thrust curvature relationship equations indicate that, in the case of constant axial thrust in the elastic range, there is a linear relationship between the applied moment and the resulting deformation. For greater values of applied end moment, yielding will occur at the most highly strained section along the member.

For the determination of the maximum carrying capacity of the member, the load-deformation relationship is defined by a numerical integration procedure, by assuming deflection values and successively correcting these assumptions. The process is repeated until the desired accuracy of the deflected shape is obtained. Finally, interaction curves relating the axial thrust, applied end moment and slenderness ratio are developed for the ultimate carrying capacity of the columns.

The comparison between the predicted strength of the columns, expressed by the interaction curves, and available experimental data generally indicates very good correlation.

M. S. Troitsky, Canada

3894. Neffson, B. A., Beam columns on elastic supports, *J. Aero/Space Sci.* **26,** 4, 255–256 (Readers' Forum), Apr. 1959.

3895. Hechtman, R. A., Hattrup, J. S., Styer, E. F., and Tiedemann, J. L., Lateral buckling of rolled steel beams, *Trans. Amer. Soc. Civ. Engrs.* **122,** 823–843, 1957.

3896. Kovalenko, K. P., The effects of internal and external friction on the dynamic stability of bars, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 2, 345–358, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

From properties of solutions of Hill's equation, $y''(x) + \lambda p(x)\, y(x) = 0$, a well-known, and to some extent embarrassing, result derives regarding the stability of a bar under pulsating axial thrust: unstable conditions may arise even when the mean value of thrust is less than Euler's critical value and the amplitude of the pulsating portion is very small, if the frequency of pulsation ($\sim \lambda^{-\frac{1}{2}}$) happens to be chosen low enough, within some very narrow specified intervals. This "paradox" arises because, under the exceptional circumstances mentioned above, the nonconservative thrust does positive work, which leads to a steady, if slow, increase in the kinetic energy of the bar; it may be thought then that damping effects may restore stability.

Author uses rather delicate estimates of behavior of the characteristic function of Hill's equation for large values of λ to show that the paradox cannot be avoided by taking into account linear external damping. Instead, the introduction in the equation of motion of a term representing linear internal damping modifies the response and a limit frequency can be found below which instability cannot arise.

G. Capriz, England

3897. Volvich, S. I., The stability of girders in the nonelastic region (in Russian), *Sb. Nauchn. Soobshch. Saratorsk. Avtomob.-dor. In-ta* no. 7, 3–13, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10362.

A generalization of the variational equations of the stability of girders developed earlier by the author. The variations in the forces on the bars and the angles of rotation are presented in the form of a linear function n, of the independent, virtual states of the system, caused by the action of simple or group forces. Applying the variational criterion of stability and the condition of minimum critical loading, author obtains a system of homogeneous equations, the principal determinant of which defines the equation of stability of the system. Allowance is made for the possibility of elastic-plastic deformation of the girder at the instant of loss of stability. Rigorous methods of analysis of the general stability of girders are illustrated on an example of the simplest form of "Mises girder".

V. K. Erupov

Courtesy Referativnyi Zhurnal, USSR

3898. Gregory, M., The use of the Southwell plot on strains to determine the failure load of a lattice girder when lateral buckling occurs, *Austral. J. Appl. Sci.* **10,** 4, 371–376, Dec. 1959.

Author has carried out tests on a model lattice girder. It is observed that the equation of the Southwell plot on strains in the compression chord is of the same form as the usual column formula. Further it is hoped that carrying out of the Southwell plot on various types of structures would establish necessary empirical information for this equation to be useful in design. For a girder treated as a beam with continuous web the calculated value of the critical load is found to be in close agreement with the measured value.

A. M. Sen Gupta, India

3899. Reckling, K.-A., Contribution to the theory of plate buckling in the plastic region (in German), *Ing.-Arch.* **28,** 263–276, Mar. 1959.

The theory of plate buckling is generalized to be applicable to Prandtl-Reuss material having orthogonal anisotropy. Thus the derived fundamental equations are based on an incremental rather than finite law of plasticity. The stability criterion is based on Shanley's hypothesis. The manufacturing process of rolling of plates is assumed to cause anisotropy. The theory is applied to the solution of rectangular plates subjected to normal in-plane-stresses on the boundaries. Comparison of the established results with limited experimental data appear to show that anisotropy caused by rolling may account for the discrepancy normally found between buckling loads based on the incremental law of plasticity and experiment. The paper is recommended to readers interested in the plate-buckling problem.

E. P. Popov, USA

3900. McKenzie, K. I., The buckling of a circular plate with a concentric circular hot-spot, *J. Roy. Aero. Soc.* **64,** 590, 105–106 (Tech. Notes), Feb. 1960.

3901. Klein, B., Review of design information on buckling of unstiffened thin walled circular cylindrical shells, *ARS J.* **30,** 1, 7–13, Jan. 1960.

3902. Schnell, W., and Bruhl, C., The orthotropic circular cylindrical shell with internal pressures under axial loads (in German), *Z. Flugwiss.* **7,** 7, 201–207, July 1959.

The critical axial load for orthotropic shells under internal pressure is calculated by means of the linear theory. The displacements are assumed in the form of a product of two simple harmonics with unknown amplitudes and wavelengths.

If the internal pressure is zero, then for the shell with "longitudinal bracing" the waves are prolonged axially and transversely for the shell with "transverse bracing." The critical load does not change if the rigidities are taken in inverse ratio.

The internal pressure causes a lengthening of waves in the transverse direction. The critical load increases with internal pressure, rapidly for the "longitudinal" and moderately for the "transverse bracing" of the shell.

The experiments were carried out with cylinders of three-layer plywood, diameter 390 mm, length 1000 mm, thickness 0.6 and 0.8 mm. The results are plotted by 28 points in two graphs with critical load versus internal pressure. The general trend of these graphs confirms the theoretical conclusions, although the waves are not uniformly distributed. However, the theoretical critical values are higher by about 20%.

I. Hlavacek, Czechoslovakia

3903. Moe, J., Stability of rib-reinforced cylindrical shells under lateral pressure (in English), *Publ. Int. Assn. Bridge Struct. Engng.* **18**, 113–136, 1958.

Author extends the method of Stein, Sanders and Crate [AMR **4** (1951), Rev. 2425] for analysis of buckling of ring-stiffened cylinders to the case of lateral pressure. Analysis is based on Donnell's linear theory with the classical (though unrealistic) assumption of a pure membrane state of prebuckling stress. Solution is obtained by the Galerkin method for a simply supported cylinder and results are shown for the lowest (general instability) circumferential buckling stress for any number of rings as a function of ring bending stiffness. Optimun ring stiffness for simultaneous general and panel instability is also shown.

R. W. Leonard, USA

3904. Khuan, K.-C., On stability of a compressed bar in creep (in Russian), *Scientia Sinica* **8**, 8, 794–801, Aug. 1959.

This paper deals with the buckling problem of an initially straight, simply supported bar of an ideal I-section (buckling in the plane of the web). The relation between stress σ and strain ε is assumed in the form

$$\varphi(\varepsilon) = \sigma(t) + \int_0^t K(t-\tau)\,\sigma(\tau)\,d\tau$$

where $K(t)$ is the "memory" or "heredity" function of the material, $\varphi(\varepsilon)$ is some characteristic function of strain, being nonlinear for increasing strain and linear for decreasing strain, t is time. The results are given in the form of the critical time after which buckling occurs for a given axial force. It should be noted that the conclusions of this paper are closely related to the assumed properties of the material.

M. P. Bieniek, USA

3905. Schlechte, F. R., Theoretical analysis of the creep collapse of columns, NASA TN D-95, 46 pp., Sept. 1959.

Title problem is solved by use of creep variational theorem previously developed by author and colleagues from analogous elasticity theorem proposed by Reissner [*J. Math. Phys.* **29**, 90–95, 1950; ibid, **32**, 129–135, 1953; AMR **7**(1954), Rev. 1042]. Solid rectangular and idealized H-section columns are considered, both linear and nonlinear stress distribution being assumed for rectangular section. Charts are given for critical lifetime parameters based on these various theories.

Previously published experimental data for rectangular section columns are used as basis for comparison. Author found that there is little to choose between linear and nonlinear stress assumption and that good estimates can be obtained from an approximate tangent modulus method.

J. M. Alexander, England

Vibrations of Solids

(See also Revs. 3778, 3798, 3802, 3876, 3983, 4002, 4003, 4004, 4175, 4289, 4292)

3906. Fichter, W. B., and Kordes, E. E., Investigation of vibration characteristics of circular-arc monocoque beams, NASA TN D-59, 27 pp., Sept. 1959.

Symmetric, and antisymmetric, bending and torsion modes of two 4% thick circular arc monocoque beams, differing only in skin thickness, were determined experimentally and were computed using a theory which assumed the cross sections of the beam to be rigid. The agreement between experimental and theoretical natural frequencies is good for the first six bending modes in the thick-skinned beam, but poor for all but the first modes in torsion in both beams and in bending in the thin-skinned beam.

The discrepancy is attributed to panel vibrations and the effects of transverse shear and shear lag.

M. Botman, USA

3907. Karyakin, N. I., The constrained and free torsional vibration of multiple-span, thin-walled beams (in Russian), *Sb. Naucbn. Rabot Vyssb. Shkola Promsl. Kooperatsii* no. 4, 3–13, 1957; *Ref. Zb. Mekb.* no. 8, 1958, Rev. 9094.

On the basis of the analogy between the differential equations of constrained torsion and longitudinal-transverse bending respectively, a "dynamic equation of three bi-moments" is set up for the problem of the free and constrained torsional vibrations of a multiple-span, thin-walled beam. Two illustrative examples are presented.

V. V. Bolotin

Courtesy Referativnyi Zhurnal, USSR

3908. Kondratiev, A. S., and Christovskaya, N. I., The oscillations of loaded beams (in Russian), *Sb. Naucbn. Trudi Kuibyshevsk. Industr. In-ta* no. 7a, 9–29, 1957; *Ref. Zb. Mekb.* no. 8, 1958, Rev. 9106.

The natural transverse vibrations of rectilinear beams are investigated under different conditions of end constraint. Applying the resolvent of the influencing function of the beam, authors obtain frequency equations for beams of constant rigidity, loaded by a concentrated mass. Comparing the frequencies first obtained by means of rigorous equations, and the approximate solutions, the accuracy of the latter is evaluated. Two cases of end constraint are investigated: (1) Both ends hinge-supported; (2) One end fixed, one end free. Equations of the resolvent are given for a beam with one end fixed and one end hinged, and for a beam with both ends rigidly held. These expressions enable the frequency equations to be set up for both these cases.

S. M. Zavartsev

Courtesy Referativnyi Zhurnal, USSR

3909. Reggini, H. C., Flexural vibrations of a beam: numerical calculation of the first natural frequency (in Spanish), *Cienc. y Tecn.* **127**, 637, 101–113, Mar./Apr. 1959.

Tutorial article applies matrix methods and Stodola's approach to beam in flexure on simple supports.

J. C. Burgess, USA

3910. Greenspon, J. E., Flexural vibrations of a thick-walled circular cylinder according to the exact theory of elasticity, *J. Aero/Space Sci.* **27**, 1, 37–40, Jan. 1960.

Paper provides additional numerical results for author's exact solution of flexural vibration of finite-length hollow cylinder restrained circular at ends. Original discussion was given in Proc.

of Third National Congress of Applied Mechanics, 1958 [AMR **12** (1959), Rev. 5997]. New results for mode with one circumferential wavelength reveal that frequencies predicted by Arnold and Warburton's thin shell theory are highly accurate for $r_o/r_i = 0.98$ for even relatively short cylinders: say, outside diameter about 1/6 longitudinal wavelength. For $r_o/r_i = 0.9$, agreement extends only to about 1/2 wavelength. For very thick shells, say $r_o/r_i = 0.01$, the Timoshenko beam theory, using 0.9 shear constant, is accurate for even short cylinders. For intermediate thicknesses and relatively short cylinders, both approximations are inaccurate. The author notes that some of the thick-walled shell theories may yield more accurate results in the intermediate thickness range. Agreement between stresses predicted by the exact and various approximate methods may be poorer. The principal value of this exact analysis is for checking the various approximate methods which are far more amenable to practical application.

J. E. Corr, USA

3911. Bishop, R. E. D., The vibration of rotating shafts, *J. Mech. Engng. Sci.* **1,** 1, 50–65, June 1959.

This paper is the first of a series whose purpose is to relax the usual assumptions in the analysis of shaft vibration. The formulation of a more complete theory suggests a method of balancing flexible shafts, a fresh approach to the problems of stability and a way of allowing for bearing characteristics; it also suggests methods of allowing for lack of axial symmetry. Use is made in this exposition of the mechanical analogy which exists between an initially bent shaft and a simple conical pendulum whose point of support is given a circular motion in a horizontal plane.

From author's summary by H. Deresiewicz, USA

3912. Bishop, R. E. D., and Gladwell, G. M. L., The vibration and balancing of an unbalanced flexible rotor, *J. Mech. Engng. Sci.* **1,** 1, 66–77, June 1959.

The motion of a flexible unbalanced rotating shaft is examined. The effects of balancing such a shaft (as a "rigid body") in a conventional low-speed balancing machine are explained. The underlying theory of a general method of balancing flexible rotors, mode by mode, is then given. The paper contains a discussion of the effects of dead weight on the deflection of a rotating shaft.

From authors' summary by H. Deresiewicz, USA

3913. Kazanceva, G. E., On the vibrations of circular plates of variable thickness (in Ukrainian), *Akad. Nauk UkrainRSR Prikl. Mekh.* **4,** 2, 197–204, 1958.

Taking a plate of uniform thickness as a subsidiary problem and making use of the reciprocity theorem, a Fredholm integral equation of the second type is obtained for the static deflection of a circular plate of variable thickness under a concentrated transverse load. The integral equation is further used as a subsidiary relation, in conjunction with the reciprocity theorem and the Laplace-Carson integral transformation, to arrive at an integral equation for transverse deflections of a circular plate of variable thickness in vibration. Application is made to a sector of an annulus.

W. W. Soroka, USA

Courtesy Mathematical Reviews

3914. Singh, B. R., and Nandeeswaraiya, N. S., Vibration analysis of shrouded turbine blades, *J. Instn. Engrs., India* **40,** 1 (Part 2), 1–6, Sept. 1959.

Authors assume certain simplifications so that the problem may be treated as a statically indeterminate structure. The number of blades is assumed to be very large. From the differential equations a frequency equation is obtained and this is solved by expanding the terms in a power series to determine the natural frequency ω_1, both in the plane of the disk and perpendicular to it, and of ω_2 that introduces the modification for centrifugal forces while flexural rigidity is ignored. O. Bottema, Holland

3915. Kissel, W., The lowest natural bending frequency of a rotating blade of uniform cross-section (in English), *Escher Wyss News* **31,** 3, 28–29, 1958.

Paper presents the derivation of a modified Southwell speed factor, usually applied when the increase in natural frequency caused by centrifugal forces of rotating blade is to be determined. The assumption is made that the plane of vibration of the blade does not coincide with the plane of revolution.

Using a five-degree polynomial approximation (containing one free parameter) for the blade deflection form, the minimum of the Lagrange function with respect to k is found. The speed factor obtained in this manner in comparison with Schilhansl centrifugal force coefficient contains moreover a small expression which depends on the speed of the machine.

The use of derived speed coefficient is very easy and leads very quickly to good results, the error of which [about 0.1% in freq.], following from a series of calculations made by Escher Wyss, is well below the limit set for technical accuracy.

K. Julis, Czechoslovakia

3916. Saunders, H., and Paslay, P. R., Inextensional vibrations of a sphere-cone shell combination, *J. Acoust. Soc. Amer.* **31,** 5, 579–583, May 1959.

Authors use Rayleigh inextensional theory for thin shells to predict natural frequencies of sphere-cone combination supported as a bell. Displacements at sphere-cone junction are matched, but slopes are not. For a particular case, experiment and theory agree within 5% for first five modes.

J. C. Burgess, USA

3917. Carnegie, W., Vibrations of rotating cantilever blading: theoretical approaches to the frequency problem based on energy methods, *J. Mech. Engng. Sci.* **1,** 3, 235–240, Dec. 1959.

Author determines an expression for the increase of potential energy due to centrifugal effects of a vibrating cantilever blade, (mounted encastré) at the root on the periphery of a rotating disk. By use of Rayleigh's method an approximation for the lowest frequency can be obtained; the example of a straight cantilever blade of uniform and symmetrical cross section is worked out and the frequency is given as a function of the stagger angle. The equations of motion for the blade are derived from Hamilton's principle.

O. Bottema, Holland

3918. Khvingiya, M. V., Small axial oscillations of conical and shaped springs (in Russian), *Vopr. Proyektin, Izgotovleniya i Sluzhby Pruzhin,* Moscow-Leningrad, Mashgiz, 1956, 86–112; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9318.

It is assumed that no clashing of the spring turns takes place during oscillation. The springs are regarded as bars of mass and rigidity varying along the length. The integration of the equations of motion of such a bar in Bessel functions is demonstrated. In a particular case, variational analysis is also used. Tables of characteristic data for springs of different kinds are included.

V. L. Biderman

Courtesy Referativnyi Zhurnal, USSR

3919. Skowronski, J., and Ziemba, S., The problem of boundedness of motion in certain mechanical systems, (in English), *Proceedings of Vibration Problems, Polish Acad. Sci.* no. 1, 67–81, 1959.

Motion of structural model, with constraints providing sufficient number of additional equations for unequivocal determination of unknowns, is analyzed in 3-m dimensional real, Euclidean, configuration space (m = number of material points in system) under action of forces expressible as bounded analytic functions of finite displacement, velocity and time.

It is shown that nonautonomic vibrating system, having marked nonlinearity and positive energy dissipation, is describable by

finite form of motion of a bounded character. The form of motion has a certain limit state determined by initial conditions, to which all phase trajectories tend asymptotically with time. For periodically acting external forces, the trajectory of the limit state of system is shown to have the same period.

N. A. Weil, USA

3920. Troitskii, V. A., Analysis of the free oscillations of three-dimensional bar frames by the method of dynamic rigidities (in Russian), *Nauchno-tekhn. Inform. Byul. Leningrad, Politekhn. In-ta* no. 5, 3–7, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10323.

The method is based on the division of the frame system into individual elements. Expressions are given for performing the transition from the matrix of the individual dynamic rigidities of the separate elements to the matrix of the dynamic rigidities of the frame system, for the cases of series and parallel linkage respectively. Any three-dimensional bar frame is regarded as a combination of elementary bars linked in series and in parallel, and the matrix of the dynamic rigidities of this system is constructed by these formulas. The condition of equality to zero of the determinant of this matrix furnishes the values of the frequencies of free oscillation of this system. The author points out the unsuitability of combining the dynamic rigidities of the system in an explicit form, and recommends calculation of the dynamic rigidity for each value of the rigidity.

M. L. Kempner

Courtesy Referativnyi Zhurnal, USSR

3921. Syssoyev, V. I., The oscillations of systems with curvilinear elastic characteristics (in Russian), Researches on dynamics of structures, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt. 1957, 93–115, *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10333.

Methods of determining the frequency of oscillation are examined relating to systems supported on elastic abutments with a cube-law relationship between the reactions and the displacements. (The particular problem considered is the determination of the frequency of oscillation of a smoke stack, stayed by ponderable guys.) For a system with one degree of freedom, the problem is reduced to an equation of the form $y'' + \lambda^2 y + \delta f(y) = 0$, with the initial conditions $y(0) = y_0$, $y'(0) = 0$; (λ^2, δ = constants; $f(y)$ a polynomial with a small number of terms). A method for solving this equation was indicated by A. N. Krylov [Coll. Wks, Vol. 10 "Vibration of ships," Akad. Nauk SSSR, 1948–1951]. The solution obtained by Krylov has been extended by the author to the case of systems with two or more degrees of freedom. The system of differential equations of the problem is in such a case reduced to Lagrange equations of the second kind, i.e., the solution is obtained in normal coordinates referred to the zero approximation. Detailed solutions are developed for the cases of two and three degrees of freedom. As a numerical example the natural frequency of oscillation is determined for a simple row of guys, which can be reduced to a system with two degrees of freedom. The results of the analysis show that nonlinearity increases the frequency of oscillation by 12%, with an amplitude of oscillation at the point of attachment of the guys of ~ 0.5m.

A. A. Pikovskii

Courtesy Referativnyi Zhurnal, USSR

Wave Motion and Impact in Solids

(See also Revs. 3896, 3904, 3910, 3984, 4147, 4367)

3922. Miranker, W. L., The wave equation in a medium in motion, *IBM J. Res. Devel.* **4**, 1, 36–42, Jan. 1960.

A model for the transverse vibrations of a tape moving between a pair of pulleys is devised using a variational procedure. It is shown by means of energy-type integrals that the energy of that portion of the tape between the pulleys is not conserved, but that there is a periodic transfer of energy into and out of the system. The solution for the wave equation is then constructed by a method which makes use of functional equations. The solution is observed to be periodic in time, and a model decomposition of it is derived. A solution is also derived for the case of forced vibrations at the pulleys, and a class of forcing vibrations which cause unbounded solutions as time increases is isolated. In an appendix, a boundary-layer effect is considered which occurs when the velocity of the tape through the pulleys approaches the speed of sound in the tape.

From author's summary by G. A. Nariboli, India

3923. Gilbert, F., and Knopoff, L., Scattering of impulsive elastic waves by a rigid cylinder, *J. Acoust. Soc. Amer.* **31**, 9, 1169–1175, Sept. 1959.

A plane strain solution in terms of displacements is obtained in integral form by formal application of one- and two-sided Laplace transforms to the problem of the scattering of compressional elastic waves from an impulsive line source parallel to the axis of a rigid, infinitely dense, cylinder imbedded in an isotropic, homogeneous, perfectly elastic medium of infinite extent. The bulk of the paper is concerned with the inversion of the solution from the iterated Laplace transform plane to the real plane by using asymptotic approximation of the integrand and the Cauchy residue theorem. The results show the presence of a diffracted P wave and a diffracted S wave in the shadow region and the usual direct P and diffracted P and S waves in the illuminated region. A familiarity with Bessel functions and modified Bessel functions is requisite to reading the paper.

W. C. Orthwein, USA

3924. Einspruch, N. G., and Truell, R., Propagation of traveling waves in a circular cylinder having hexagonal elastic symmetry, *J. Acoust. Soc. Amer.* **31**, 6, 691–693, June 1959.

Authors study the propagation of waves in a crystal of specific elastic properties. The stress-strain law is derived from the strain energy and a cylindrical system is chosen such that the z axis coincides with the axis of elastic symmetry and the geometrical axis of the cylinder. Equations are formed for the radial and torsional displacements where the solutions are plane waves. A factorization technique is used and the solutions are indicated, which involve Bessel functions of the first kind, of order 0 and 1. Boundary conditions are applied, yielding nontrivial solutions which indicate that the compressional and torsional waves propagate independently of each other. The isotropic case is considered and the solution of the wave propagation problem is identical to the case of the rod as studied by W. P. Mason.

G. E. Jarlan, Canada

3925. Tamato, O., On the propagation of elastic waves along the circular cylindrical surface of an infinitely long solid, *Technol. Rep. Tohoku Univ.* **21**, 1, 77–91, 1956.

Exposition of subject matter is lucid and scholarly, applying well-established concepts of theoretical mechanics to setting up an equation-of-motion for the propagated elastic wave. Solution for this particular equation is obtained in terms of Bessel functions. Contour integration is explained and carried out over diametrical sectors of a cylindrical cross section. The algorithm is discussed, more in particular the determination of the roots of a polynomial expansion applied to certain complex variables utilized in the contour integrations. The special case of wave propagation in very large cylinders is treated in detail, as is the opposite extreme, a very thin cylinder. Aperiodic sources of disturbance are explored mathematically for the case where the primary perturbation is caused by an impulse of short duration. Author compares his own method of treating the problem of elastic pulse propagation in an infinite solid with other procedures. The discussion of wave

dynamics is precise throughout the article, but requires on the part of the reader considerable steeping in the numerical methods utilized by this particular bailiwick of the theory of elasticity.

E. L. Eichhorn, USA

3926. Hathaway, M. E., Water impact loads on prismatic bodies, Proceedings of the Seventh Hydraulics Conference, Iowa Institute of Hydraulic Research, June 16–18, 1858; Iowa City, Iowa, State Univ. of Iowa, 1959, 163–181.

Paper presents theoretical and experimental data, obtained during investigations at the NACA, concerning the impact of rigid prismatic bodies on smooth water surfaces. The bodies used have straight-sided V-shaped bottoms, moving at fixed trim. The investigation covers two types of impact. One deals with impact when there is no chine immersion of the body, and the other treats the case when the chines are immersed early in the impact before maximum load is reached. Generalized variables are used in presenting the results. The impact of partly immersed chines is not treated in the paper.

Satisfactory agreement has been obtained between theory and experiment for a large range of impact conditions of both types. For a given geometry of body and flight, it is shown for both types of impact that the draft is independent of velocity, the acceleration varies as the square of the velocity, and the time is inversely proportional to the velocity. The effect of weight, at impact without chine immersion, manifests itself to the cube root; while at impact with chine immersion, its effect appears to the square root. The size of the body has no effect in the impact of the first type, but it enters to the square root in the second type impact.

The paper closes with the discussion that followed its presentation. The introduction includes a brief review of previous work done in the field.

D. Abir, Israel

3927. Gvozdev, A. A., On the conditions at elastic wave fronts propagating in a nonhomogeneous medium, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23**, 2, 556–562, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Author studies the character of the displacements near the wave front defined as a surface at which the displacements undergo a finite discontinuity and move in an ideally elastic nonhomogeneous medium. The conditions for the wave front are derived generally and discussed. Particularly, relations for the rotation of the displacement vector of a longitudinal wave and the divergence of that vector of a transversal wave at the wave front are given which connect those quantities with the displacement itself, the constants of the material and the speed of propagation. An extension of the applicability for continuously varying displacement fields is indicated.

F. Engelmann, France

3928. Davydov, G. A., The calculation of fuel burner springs (in Russian), *Ucb. Zap. Leningrad Vyssb. Inzb. Morsk. Ucb-sbcbe* no. 5, 40–51, 1957; *Ref. Zb. Mekb.* no. 8, 1958, Rev. 9317.

Calculation of the springs of liquid fuel burners is performed by applying the wave theory of axial impact on an elastic bar; the spring is substituted by an equivalent, rectangular bar, the mass and resiliance of which correspond to the same parameters of the spring. Expressions are obtained for determining the rate of strain and the time of passage of the wave of deformation along the bar and back. The stresses in the cross sections of the spring are determined. The deviation of the calculated stresses from the experimental values is of the order of 5 to 6%.

N. P. Kashparova

Courtesy Referativnyi Zhurnal, USSR

3929. Orner, G. M., and Hartbower, C. E., The low-blow transition temperature, *Proc. Amer. Soc. Test. Mat.* **58**, 623–639, 1958.

In a new technique for the Charpy impact test the specimen is first given a low energy blow to start a crack from the root of the notch. This is followed by a second blow which is delivered in the normal manner. The transition temperature determined from this second blow is said to depend only on the material tested and to be the maximum temperature at which a crack can become self-propagating in a thick plate. This claim cannot yet be accepted without reservation but the lively discussion of the paper is evidence of a keen interest in the new suggestion.

A. F. C. Brown, England

3930. Rochniatovsky, A. F., The impact analysis of a bar of variable rigidity with a curved axis (in Russian), *Nauchn. Trudi Mosk. Inzb.-Ekon. In-ta* no. 7, 76–84, 1957; *Ref. Zb. Mekb.* no. 8, 1958, Rev. 9099.

A method is demonstrated for calculating the equivalent mass of a curvilinear bar at the point of impact, with approximate determination of the dynamic flexure. The equivalent mass is obtained by the usual methods applicable to rectilinear beams. The velocities of points on the beam in the direction of impact are assumed to be proportional to the displacements of the cross sections under static loading. The displacements are calculated with the help of the Mohr integral. Two cases are examined: a beam with a circular axis of constant, and of a variable cross section. The experimental results diverge from the corresponding analytical values of the bending deflection by less than 3%.

Yu. P. Grigor'ev

Courtesy Referativnyi Zhurnal, USSR

3931. Rakhmatulin, Kh. A., On the elasto-plastic wave propagation in a half-space, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23**, 3, 601–609, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

The problem of wave propagation in an elastic and in an elasto-plastic half-space produced by a given pressure acting on the limiting plane is discussed with the assumption that transversal displacements may be neglected. The purely elastic case is treated in detail, and as an example the sudden application of a constant axisymmetric load is solved. For the elastoplastic case an approximate solution of the problem is presented.

F. Engelmann, France

3932. Chakraborty, S. K., Disturbances in different types of elastic media, *Geofis. Pura Appl.* **35**, 25–32, Sept.-Dec. 1956.

The author considers the disturbances produced in an infinite medium when dynamical pressures are applied to the surface of a spherical cavity within it. Three special cases are considered: (a) The medium is assumed to be elastic and isotropic but to offer a resistance to the motion directly proportional to u, the displacement vector. By assuming that u can be expressed as grad ϕ, solutions are derived for the cases in which the applied radial pressure is periodic in the time, and is constant at $t = 0$. (b) The medium is again supposed to be elastic but transversely isotropic about the radius vector; here the applied radial pressure is assumed to be impulsive. (c) The medium is assumed to display a certain type of linear viscoelasticity; only general remarks are made, no assumption being made about the precise nature of the applied pressure.

I. N. Sneddon, Scotland

3933. Kukudzanov, V. N., Shock waves in a compressible visco-plastic medium (in Russian), *Izv. Akad. Nauk ArmyanSSR, Ser. Fiz.-Mat. Nauk* **11**, 6, 61–72, 1958.

This paper presents a theoretical study of the problem of the dynamic expansion of a cavity, either spherical or cylindrical in shape, in a visco-plastic medium. The magnitude of the pressure applied at the surface of the cavity is supposed such that a shock wave occurs. The most significant feature of the investigation is that, within the framework of an apparently conventional theory, due attention is given to the occurrence of a discontinuous change

in density, corresponding to the existence of a shock front. Some attention is given to definite physical situations, but few numerical results are given.

H. G. Hopkins, USA

Courtesy Mathematical Reviews

Soil Mechanics: Fundamental

(See also Rev. 3839)

Book—3934. Bekker, M. G., Theory of land locomotion—the mechanics of vehicle mobility, Ann Arbor, University of Michigan Press, 1956, x + 520 pp. $12.50.

Book scientifically approaches locomotion of animals and men in nature, motion on wheels, morphology of automotive vehicles and environment, problems of soil and snow mechanics, wheel mechanics, crawlers of track-laying vehicles, skis, sleighs and toboggans, mechanics of a motor vehicle, trafficability of soils, performance of vehicles and economy of locomotion, and scale-model testing. The work penetrates deeply into the essentials, extending widely into the unknown and attacking the open problems in new ways of scientific approach on the basis of literature which is amply and thoroughly referenced. It is an excellent introduction and orientation for engineers, informative on the limits of evidences available and giving an outlook into research problems of the future.

The author opens the way to engineers for realizing optimal performance and efficiency of off-road vehicles for any purpose and for adapting them to operational conditions. Important is the help the work gives to designers for setting up and evaluating scale-model tests.

W. I. E. Kamm, Germany

3935. Florin, V. A., The unidimensional problem of the compacting of waterlogged soils in the presence of creep (in Russian), Proceedings of the 4th International Congress on Soil Mechanics and Foundations, Moscow, Akad. Nauk SSSR, 1957, 197–203; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10419.

The unidimensional problem of the compacting of waterlogged soils is reduced to the solution of a partial differential equation with constant coefficients. Allowance for creep of the soil skeleton is made by applying the theory of an elastically-creeping body [N. Kh. Arutyunian, "Some problems of the theory of creep," Gostekhteorizdat, 1952]. From the solutions for some problems the author concludes that the introduction of the influence of soil creep and the initial thrust pressure in the investigation of soil consolidation may in some cases be essential.

S. R. Meschyan

Courtesy Referativnyi Zhurnal, USSR

3936. Kogan, B. I., Stresses and strains in road surfaces with a continuously-varying modulus of elasticity (in Russian), *Trudi Kharkovsk. Avtomob.-Dor. In-ta* no. 19, 53–66, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10432.

The problem is examined of the stress conditions in a double-layer, elastic semispace, wherein the modulus of elasticity E, and the Poisson ratio μ, in the top layer, are defined by continuous functions of the depth, while in the underlying layer, they are constant. On the free surface, an axially-symmetrical, normal load is postulated, represented by a Fourier-Bessel integral. Author uses the results obtained in his previous paper [*Trudi Kharkovsk. Avtomob.-Dor. In-ta* no. 4, 33–46, 1953] in which, for the i-th homogeneous layer of a multiply-stratified semispace under analogous loading, the stress function was represented in the form

$$\chi_i(r, z) = \int_0^\infty F(A_i, B_i, C_i, D_i, r, z, k)\,dk$$

while, for the determination of the functions $A_i(k), \ldots, D_i(k)$, linear equations are set up, ensuring the continuity of the stress condition at the boundaries of the layers. For a sufficiently small thickness of each layer, equations are derived in terms of finite differences for determining the functions $A(z, k), \ldots, D(z, k)$. In the limit these equations become a system of differential equations. In the case that μ = const, and $E(z)$ in the top layer is defined in the form $E = \gamma_{exp}\beta_z$, the problem is reduced to equations with constant coefficients, the solution whereof can be obtained by Picard's method of successive approximations. It is suggested that the parameters γ and β be selected in such manner as to obtain the least mean-square deviation of the function $E(z)$ from the values of E given for particular depths. In some of the expressions, identical symbols on the left- and right-hand sides have different meanings.

Ya. B. L'vin

Courtesy Referativnyi Zhurnal, USSR

3937. Voronov, F. I., Methods of determining the plasticity of soils (in Russian), *Zap. Uzbekist. Otd. Vses. Mineralog. O-va* no. 11, 81–96, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10418.

The known data on the plasticity of soils are recapitulated and the relevant classifications are given; author suggests his own classification in which the characteristic degree of plasticity of a soil is correlated with its grain-size classification. Existing methods are described for determining the limits of plasticity, and a method is suggested closely resembling that of P. O. Boychenko (In: "Some methods of determining the physical and mechanical properties of soils," Leningrad, LGU, 1950, 5–32]. The incorrectness of the method of determining soil resistance by the ratio between the plasticity limits and the natural moisture content, which does not take into consideration the essential features of soil structure, is pointed out. A critical survey is made of the existing methods of determining the consistency of soils.

G. I. Ter-Stepanyan

Courtesy Referativnyi Zhurnal, USSR

3938. Hsu, C.-I., A new apparatus for the determination of the coefficient of lateral earth pressure at rest (in English), *Scientia Sinica* **7**, 6, 648–660, June 1958.

Soil Mechanics: Applied

(See Rev. 4363)

Processing of Metals and Other Materials

(See also Revs. 3824, 3825, 3954, 3974, 4015, 4343)

Book—3939. Gruner, P., Rolling of hollow-stock and roll designing in manufacturing of seamless tubes [Das Walzen von Hohlkorpern und das Kalibrieren von Werkzeugen zur Herstellung nahtloser Rohre], Berlin, Springer-Verlag, 1959, viii + 301 pp. DM 52.50.

Manufacturing processes of seamless tubes have made great progress in recent years, and fine tubular products manufactured in modernized steel works are now on the market. Proper understanding of the processes, however, does not prevail even among metal-working engineers. The book is written to fill the gap.

A short introductory chapter (Chap. A) giving definitions and some explanative examples of roll designing is followed by a chapter (Chap. B) which deals with causes of defects or troubles encountered in rolling of hollow-stock. Causes of defects are grouped into three classes, and subdivided into nine items. In Chap. C are briefly discussed the design and arrangement of dies

(or die train) in tube drawing and tube extrusion, and in Chaps. D and E author deals with roll designing for hot and cold pilger rolling (i.e. reciprocating rolling process) respectively. Rolling of section iron bars with a central circular hole and radial rolling process of large-diameter tube are included in Chaps. F and G.

A good deal of the book is devoted to succeeding five chapters which concern manufacturing of seamless steel tubes by Stiefel-Mannesman process. Rotary piercing mill, reducing mill and straightening process are discussed in detail (plug-mill rolling is not included). Theoretical treatment of mechanics and roll designing of oblique roll straightener, which is the essence of the book, would arouse attention of research workers as well as mill specialists.

Book closes with a chapter by W. Lohman which accounts for the mechanism or trick of rotary piercing process. This chapter is mathematical, and a proof is given for the formation of hole in the process viewed in the light of elasticity theory.

Reviewer believes book is a valuable addition to the technical literature and the aim of the author is practically attained.

Bibliography is mostly in German; index, not presently included, would make use of the book much easier.

Y. Yamada, Japan

3940. Hattori, T., A treatise on the screw extrusion of thermoplastics. Parts 1 and 2, Theory of the screw extrusion of non-Newtonian liquid; Experimental studies about the extrusion of polyethylene, *Bull. JSME* **2**, 7, 475–486, Aug. 1959.

Theories of screw extrusion have hitherto been limited to a Newtonian fluid or Bingham material. The present paper is concerned with non-Newtonian fluids in which there is a power-law relation between strain-rate and stress in pure shear. The theory presented is of an elementary type and the agreement with the experimental data on polyethylene is only moderate. The comparison is complicated by a temperature variation along the container as the material changes from semimolten and partially mixed to fully molten and thoroughly mixed. Data on pressure distribution and discharge rate are comprehensively presented.

R. Hill, England

3941. Yoshimoto, I., The rolling pressure of the flat die type thread rolling machine, *Bull. JSME* **2**, 7, 495–499, Aug. 1959.

The theoretical analysis of A. Yamamoto [*Bull. Tokyo Inst. Technol. (A)* **1**, 1, 1957] for the force normal to the die surface in the thread rolling process is developed on the assumption that the deformation is infinitesimal in each passage between the dies. Author extends the method to cover applications of the process in which the total number of passages is small, the deformation in each passage being finite. Author makes no change in the basic assumption that the force at any instant is the product of a (constant) deformation resistance and the total projected area in contact with the die. A comparison is made with experimental results obtained some years ago in Germany by Reichel.

G. D. S. MacLellan, Scotland

3942. Tanaka, E., and Yoshiki, T., Study on the rolling of metals and alloys with Sendzimir reversing cold strip mill: Part 1, Pattern of waves appearing on the metal foils, *Sci. Rep. Res. Inst. Tohoku Univ. (A)* **10**, 6, 405–413, Dec. 1958.

Authors investigate conditions which produce a system of regularly spaced waves on the surface of foil when using this type of mill. It was established that occurrence of wave pattern depends on front tension but not on back tension and that the minimum front tension which eliminates the pattern is independent of work roll material. Micro-examination and x-ray analysis revealed no difference in structure between "waved" and "non-waved" material.

Authors suggest that phenomenon is caused by center buckling of strip.

F. Ellis, England

3943. Derkach, P. Kh., and Postolnik, Yu-S., A determination of the stresses arising in the forging of bolts (in Russian), *Naucbn. Zap. Dniepropetr. In-ta* **45**, 161–170, 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9155.

In the shaping of bolts by means of automatic, two-stroke cold upsetting presses, after the first blow the cylindrical blank is shaped into the form of a truncated cone. The die cavity, in the form of a truncated cone, is referred to a spherical system of coordinates (r, θ, φ). The problem is considered to be axially symmetrical; the stress components are functions only of the coordinates r and θ. The solution is simplified and reduced to a nonlinear, differential equation in partial derivatives of the second order, with variable coefficients. It is considered that, on the lateral surface, the frictional force is uniformly distributed along the generating line, and there reaches its maximum value. The solution of the differential equation is sought by the method of characteristics. The equation for the second blow of the punch is obtained similarly. As a result, expressions are obtained for the stress distribution over the surface, and the combined (total) impact force can be calculated. Comparative calculations for the concrete case furnish a satisfactory agreement with the experimental data.

V. G. Osipov

Courtesy Referativnyi Zhurnal, USSR

3944. Matveyev, A. D., The theoretical analysis of the shaping of a thin sheet by a cylindrical punch (in Russian), Mashiny i tekhnologiya obrabotki metallov davleniyem, MVTU 79; Moscow, Mashgiz, 1957, 75–80; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10367.

The process of shaping a sheet blank by a cylindrical punch is reduced to the problem of the plastic deformation (shaping) of a blank of infinitely large diameter over a region located above the diehole. The annular region of the blank between the edges of the punch and the die is regarded as forming a thin-walled, axially-symmetrical shell with a curvilinear generating line. Application of the equations of the theory of plasticity, on the assumption that the conditions of simple loading are fulfilled, enables an expression to be set up for the stress-strain distribution over the generating surface of the blank, as well as for the equation representing the correlation between the applied force and the coordinates of points on the deformed surface.

G. A. Colntseva

Courtesy Referativnyi Zhurnal, USSR

3945. Klimenko, V. M., The problem of determining the deformation capacity of the material and the stress distribution in the rolling of large ingots (in Russian), *Trudi In-ta Cherney Metallurgii, Akad. Nauk USSR* **11**, 86–97, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10373.

Some results are presented of the experimental determination of the depth of penetration of plastic deformation and its dependence on the pressure in the blooming rolls: in the first approximation this relationship can be represented for straight carbon steels by a second-order curve. When rolling alloy-steel ingots, no great variation in their capacity for deformation was observed; this is apparently due to the diminution in the difference between the mechanical properties of different steels with increasing temperature. Some considerations are also presented on the nature of the stress distribution in the ingots during rolling.

V. A. Lomakin

Courtesy Referativnyi Zhurnal, USSR

3946. Masuko, M., and Kumabe, J., A few new methods of metal cutting to get a fine surface at low speed—sub-zero-, reversal finish-, and ultrasonic cutting, *Bull. JSME* **2**, 7, 487–494, Aug. 1959.

Paper describes and gives illustrative results for three methods of metal cutting in which particular attention is given to influence on the service between tool and workpiece. These are: (1) Cutting at subzero temperatures; (2) "reversal finish" cutting; (3) cutting

and ultrasonic vibration. For each method, there is some evidence of improvement in surface finish and/or increase in coefficient of friction. The methods seem to be more effective for the more ductile materials; however, there are some anomalies.

H. J. Grover, USA

3947. Rohonyi, V., Up-to-date dimensioning of the rotating spindles of machine tools for repetitive complex stress (in Hungarian), *Gép* **11**, 4, 121–128, Apr. 1959.

Fracture (Including Fatigue)

(See also Revs. 3929, 3971, 3972, 3975, 3988, 4015)

3948. De Kazinczy, F., Brittle and ductile fracture of metals (in Swedish), *Jernkontorets Ann.* **143**, 10, 617–645, 1959.

A critical survey is presented of recent developments in fracture theory.

Fracture always starts at imperfections; such do not pre-exist in the metal, but form during plastic deformation. A few models for brittle crack nucleation are described. In some cases crack nuclei have actually been observed.

Brittle crack growth is treated in a principally similar way as in Griffith's classic theory. Local stresses surrounding the nucleus are, however, also taken into account. Treatments are generally modified to fit concepts of dislocation theory.

The application of theory to practical cases is not quite simple. Fracture at low temperatures of plane and notched tensile bars is described in detail. For steel the ductile-brittle transition corresponding to the intersection between the fracture stress and the yield stress curve is considered to be the most significant one. The corresponding stress is the lowest one at which brittle fracture occurs. This should be interpreted as the critical normal stress of fracture theories. The transition of plane and notched bars is related through the corresponding stresses; these are proportional to each other for all grain sizes. The ratio depends on notch geometry.

Theories predict a certain relationship between grain size and critical normal stress; it is shown that this is not quite obeyed.

Fibrous fracture nucleates in a different way than brittle fracture, its growth can be looked upon as a continuous nucleation process. The essential role of plastic instability in shear fracture is pointed out. From author's summary

3949. Tseitlin, V. Z., On the determination of the rupture plasticity of heat-resisting alloys, *Indust. Lab.* **25**, 1, 92–95, Mar. 1960. (Translation of *Zavod. Lab., USSR* **25**, 1, 87–89, Jan. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

3950. Jaeger, J. C., Rock failures at low confining pressures, *Engineering* **189**, 4897, 283–284, Feb. 1960.

3951. Kurentkov, A. F., The influence of irregular heating over the height on cracking in reinforced concrete elements (in Russian), *Nauchn. Zap. Poltavsk. In-ta Inzh. S.-kh. Str-va* no. 3, 186–193, 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9279.

Author investigates the cause of cracking in rectangular, reinforced concrete beams restrained from yielding, when irregularly heated on the side opposite the reinforcement. The bending moment necessary to prevent compressive strain of the fibers on the side not directly heated is investigated. The magnitude of this moment determines the compression stresses in the beam, when prevented from yielding under the influence of heat. Comparing these stress values with the analytically determined stresses in unreinforced beams by the hypothesis of plane sections, author arrives at the conclusion that in either case the results are of the same order of magnitude. On this basis, author believes it possible to determine the temperature gradients at which the tensile stresses in the vicinity of the axis of the heated element attain the ultimate tensile limit of the concrete, and expresses the opinion that the appearance of cracks is associated with the first temperature rise. The indirect treatment of the experimental results makes the work inconclusive.

V. A. Gastev
Courtesy Referativnyi Zhurnal, USSR

3952. McEvily, A. J., Jr., and Illg, W., An investigation of nonpropagating fatigue cracks, NASA TN D-208, 29 pp., Dec. 1959.

Through consideration of the stresses existing at the tip of a fatigue crack an attempt is made to account for nonpropagating fatigue cracks. It is concluded that such cracks may form under constant-amplitude cyclic loading if the crack closes during compression or if the effective radius of the crack is larger than that of the initial notch. The results of experimental work on steel and aluminum alloys compare favorably with predictions.

From authors' summary by G. V. Smith, USA

3953. Koiter, W. T., An infinite row of collinear cracks in an infinite elastic sheet (in English), *Ing.-Arch.* **28**, 168–172, March 1959.

A solution in closed form is given, based on Muskhelishvili's general theory for the plane with a finite number of straight cuts along the same straight line. Muskhelishvili's function is rewritten for an infinite number of equal cracks spaced at constant intervals, a function which becomes in this case an infinite product.

From this development, author isolates the sine function, which permits writing the solution in closed form for the problem of an infinite row of equal cracks. Thus the discontinuity in the displacements across the crack and the increase in strain energy per crack and per unit thickness of the sheet may also be written.

An interesting feature of the solution is that the increase in strain energy is the same for shear and transverse tension if the corresponding stresses at infinity are numerically equal.

A. L. Petre, Roumania

3954. Kress, H., The production of sheet metal blades for gas turbines and compressors (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 420–434.

The use of sheet metal for the manufacture of hollow blades for gas turbines and compressors offers not only considerable advantage with respect to the methods of manufacture but also in a simple manner implies the possibility of controlling high combustion temperatures. As an example, taken from the internally cooled rider blade turbine, which was developed by the author during the latter years of the last war, for a blade, produced in 21 seconds, gas temperatures of 1000 C and circumferential velocities of 400 m/sec had been permissible. The consequences of blade failure are discussed in several examples which are illustrated by pictures.

The second part of the paper deals with a type of hollow blades, specially designed for axial compressors. The process of manufacture of these blades is described. Finally, attention is drawn to the possibilities offered by the use of welded sheet metal blades for centrifugal compressors. In two examples the author deals with an open and a closed rotor.

From author's summary

3955. Dugdale, D. S., An experimental study of the V-notch fatigue test, *J. Mech. Phys. Solids* **7**, 4, 282–287, Oct. 1959.

Rotating bending tests were carried out on sharply notched specimens of several materials. Logarithmic plotting gave *S-N* curves consisting of straight lines of a gradient common to all materials, suggesting a power law of crack propagation. When

residual stress was introduced by pre-loading the specimens, results following a similar pattern were obtained. Correlation between results of static and fatigue tests is discussed.

From author's summary

3956. Morrison, J. L. M., Crossland, B., and Parry, J. S. C., Strength of thick cylinders subjected to repeated internal pressure, Instn. Mech. Engrs., Prepr., 1959, 16 pp.

In previous papers the authors reported tests carried out on cylinders made from a 2½ per cent nickel-chromium-molybdenum steel, which were subjected to (up to) 10 million repetitions of internal oil pressure of (up to) 20 ton/in^2. Since these papers were published a considerable amount of testing has been carried out on cylinders made from a mild steel, a 3 per cent chromium steel, an austenitic stainless steel, a light alloy, a nearly pure titanium, the nickel-chromium-molybdenum steel and the chromium steel in the nitrided condition. In addition, tests of more academic significance have been carried out on the nickel-chromium-molybdenum steel in an attempt to achieve a better understanding of the extraordinary results which have been obtained.

The present paper is concerned mainly with the presentation of results (supported, of course, by ancillary tests on each material) which are of importance in design. Points of academic interest are discussed only when they are relevant to the practical problem. To make the paper reasonably self-contained, a brief summary of the previous work has been given.

From authors' summary

3957. Ouchida, H., A study of size effect on fatigue strength of steel, Proc. Second Japan Congress on Testing Materials, Kyoto, Japan, Oct. 14–15, 1958; Kyoto, Japan Society for Testing Materials, 1959, 14–18.

Paper discusses testing method for three different steels (SF-45 0.18% C, SF-60 0.35–0.40% C, and SNCM Ni-Mo, according to Japanese standards) for effecting the endurance limit and fatigue strength as a function of critical diameter of specimen. Author concludes that: (1) The size effect of plain notched specimens is large in the range of the diameter smaller than 20 mm, but in the range of 20–100 mm, the effect is comparatively small. (2) The endurance limit decreases about 10% with increase of diameter from 10–100 mm, regardless of materials (Reviewer's note: obviously author means plain specimen). The endurance limit of notched specimen having the value of stress-concentration factor equal to 3.3 decreases by about 15% for mediate steel and by 30% for 0.18% C steel and Ni-Mo steel. (3) The fatigue strength-reduction factor of the notched specimen of 100-mm diam for mild steel and medium carbon steel is considerably less than the stress-concentration factor for Ni-Mo steel but it is nearly equal to the stress-concentration factor of 3.3.

Reviewer has no doubt about the usefulness of the basic technique but questions the conclusive results based on only three alloys.

L. J. Bonis, USA

3958. Isibasi, T., and Matake, T., Fatigue strength of notched steel specimens subjected to a reversed torsion, Proc. Second Japan Congress on Testing Materials, Kyoto, Japan, Oct. 14–15, 1958; Kyoto, Japan Society for Testing Materials, 1959, 19–21.

The three kinds of threshold stresses in the fatigue strength of notched specimens are: (a) the stress at which fatigue crack develops at the root of the notch but does not propagate unless the load on the specimen is increased, (b) the stress at which a developed crack begins to propagate but stops as the crack reaches a certain depth, and (c) the stress, the repetition of which makes the specimen fracture eventually. Of the three, (a) is the smallest and (c) is the largest. The stress (a) must be taken as design stress.

Experimental results show that stress (a) as represented by τ_ω, the nominal value based on the minimum section of the notched specimen, may be determined by the following formula $\tau_\omega = \tau_{\omega 0}/\beta = \tau_{\omega 0}\,[1 + \varepsilon_0/\rho)\,]/\alpha$ where β is the fatigue notch factor, α is the elastic stress concentration factor, ρ is the radius of the notch, $\tau_{\omega 0}$ is the torsional fatigue limit of the plain specimen and ε_0 is the distance from the root of the notch to the point where the shearing stress reaches $\tau_{\omega 0}$.

K.-H. Chu, USA

3959. Hukai, S., and Takeuchi, K., On the fatigue strengths of notched specimens of industrial, pure titanium and some titanium alloys, Proc. Second Japan Congress on Testing Materials, Kyoto, Japan, Oct. 14–15, 1958; Kyoto, Japan Society for Testing Materials, 1959, 22–25.

Experimental data are reported on the fatigue properties of notched and unnotched specimens of commercially pure titanium and of three titanium alloys. In general, the fatigue limits of unnotched specimens were 49 to 63% of the tensile strength. The relation between theoretical stress concentration factor and the effective strength reduction caused by the notch was a straight line for each metal; the sharper the notch the lower the actual fatigue limit. Increasing the frequency of cyclic loading from 1700 cpm to 8000 cpm resulted in internal heating of these alloys and produced a slight decrease in fatigue limits.

T. J. Dolan, USA

3960. Delmas, R., Behaviour of heat-resistant materials for turbine nozzles under thermal shock (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1958, 190–197.

Test consisted of heating trailing edge of nozzles with controlled propane flame and cooling with air blast. Temperature cycling range was from 250 to 1150°C. Heating and cooling times were 55 and 26 secs, respectively. Materials investigated were gas turbine metallic alloys and cermets. Elastic analyses of stresses for both temperature gradient through thickness and along length of nozzle were made on basis of flate plate. F. F. Buckland [AMR **9** (1956), Rev. 1394] has made a similar analysis, breaking the nozzle into wedges. Latter analysis is more applicable to solid nozzles, former to hollow. Since heating in test is not along entire length of blade reviewer questions applicability of either analysis. Test results, therefore, are only qualitative. Most shock-resistant material was TiC cermet; most shock-resistant metal, cobalt nickel alloy surface treatment.

F. J. Mehringer, USA

Experimental Stress Analysis

(See also Revs. 3838, 3858, 3864, 3958, 4009, 4185, 4312)

Book—3961. Iosipescu, N., Introduction to photoelasticity [Introducere in fotoelasticitate] Vol. I, Bucuresti, Editura Tehnică, 1958, 190 pp. Lei 6. (Paperbound)

Book presents theoretical principles and practical conditions required for understanding the photoelastic methods. This is achieved in as short, as complete and as systematic a manner as possible within the limits of a little volume which will be soon followed by a second one entitled "Applications of photoelasticity."

The content is divided into four parts, each part including theoretical and practical notions. The first part treats two-dimensional elasticity, the second one deals with the transmission of light waves, the third discusses the double refracting phenomena and photoelasticity in general, while the fourth part presents the experimental equipment and the materials employed for this purpose. Also included in this part are the new materials obtained in Roumania and used successfully by the author for investigating the stress state by applying the fixation method.

Reviewer believes that book is a new "introduction" into the subject, useful to all those working in the field.

A. Petre, Roumania

3962. Snell, C., and Jessop, H. T., Photo-elastic exploration of the stresses in a design for a full-bore closure for a reactor pressure vessel, *J. Mech. Engng. Sci.* **1**, 2, 144-150, Sept. 1959.

The flat plate closure, perforated by a large number of holes, is designed as a compound plate. Plates at the top and bottom take tension and compression, and webs are distributed so that in addition to other functional requirements they could carry the shear force. The flow of force and the detailed stress patterns were required, for example, at the site of welds and around the holes. This indicated the use of a photoelastic model, and of "Araldite," using the three-dimensional technique of frozen stress. The results are particular to this one design. The analysis of this model shows that modern photoelastic techniques are such that highly complex machine parts or structures can be analyzed fully. The results can be applied to the prototype with confidence and to a high degree of accuracy. The information gained is fuller than could be obtained from a steel model.

G. Sonntag, Germany

3963. Jessop, H. T., Snell, C., and Allison, I. M., The stress concentration factors in cylindrical tubes with transverse circular holes, *Aero. Quart.* **10**, 4, 326-344, Nov. 1959.

Authors present a three-dimensional photoelastic S.C.F. investigation covering range of transverse whole diameter to tube diameter of 5% to 40% and inside diameter to outside diameter ratio of 0 to 90%. Experimental technique is conventional. Tubes were tested under tensile, bending, and torsional loadings.

Significant observation is that peak stress is not at the tube surface but is in the hole bore. It is disconcerting that the values of tensile loadings are appreciably lower than the results of all other investigators. The authors' statement of over-all accuracy of plus or minus 5% may be somewhat optimistic.

L. W. Smith, USA

3964. Nisbet, J. S., Brennan, J. N., and Tarpley, H. I., High-frequency strain gauge and accelerometer calibration, *J. Acoust. Soc. Amer.* **32**, 1, 71-75, Jan. 1960.

A method and apparatus are described for calibrating bonded wire resistance strain gages in the frequency range from 2 to 20 kc. The gages are mounted on an electromagnetically excited longitudinally resonant bar whose amplitude of vibration is measured by an interferometer. Results are given for one type of bonded wire strain gages. Factors affecting the frequency sensitivity relationship of bonded wire strain gages are discussed. Application for calibration of accelerometers is discussed.

From authors' summary

3965. Gur'ev, A. V., A precision electric strain gage for the measurement of transverse strains, *Measurement Techniques* no. 4, 419-421, Dec. 1959. (Translation of *Izmeritel'naia Tekhnika, SSSR* no. 4, 31-32, July/Aug. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

3966. Pian, T. H. H., Reduction of strain rosettes in the plastic range, *J. Aero/Space Sci.* **26**, 12, 842-843 (Readers' Forum), Dec. 1959.

3967. Saleeba, G. J., and Scott, I. G., Variation of the temperature coefficient of a group of strain gauges, Aero. Res. Lab., Melbourne, Austral., Note/SM 260, 6 pp., Oct. 1959.

Measurements of the temperature coefficient of resistance of twenty strain gages of the same type show wide variation in the values obtained. From authors' summary

3968. Negoro, S., On a curvilinear strain gage for stress analysis, *Rep. Res. Inst. Appl. Mech. Kyushu Univ.* **7**, 25, 47-62, 1959.

This paper contains a theoretical analysis and experimental verification of the behavior of resistance strain gages of the foil type made with their elements in spiral and circular configurations. These forms make maximum use of available surface area, allowing efficient single-layer rosettes as small as 3 mm in diameter to be made. They have the usual advantages of small gages in measuring strain at a point at the minor disadvantage of a slightly more complicated data reduction.

The experimental verification of the theory presented seems sketchy to the reviewer who believes that more work is needed to explore the possibilities and limitations of this interesting development.

P. G. Kirmser, USA

3969. Polezhayev, A. A., and Morozov, B. A., Some errors in the measurement of strains in parts for industrial metallurgical equipment (in Russian), Prokatn. Stany, no. 8, 1956, Moscow, Mashgiz, 248-254; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9300.

The errors arising in the determination of magnitude and direction of the principal stresses by strain measurements with wire gages are analyzed. Equations for the principal stresses are set up, applying to rosettes with angles of 120° and 45°. Curves of error are plotted for the σ_1 and σ_2 directions, at different ratios $\varepsilon_1/\varepsilon_2$. It is shown that the greatest error in the determination of σ_1 will arise when the difference between the ε_x and ε_y readings does not exceed the allowance for deviation in the readings of the gages from the true strain values. It is underlined that, when calculating the principal stresses and their direction by the strains measured in the rosettes, great care is needed in regard to the ratio of the principal strains, $\varepsilon_1/\varepsilon_2 < 2$; the error in the stress value may be twice the error in the strain value, and up to 80° in direction.

A. M. Sinyukov

Courtesy Referativnyi Zhurnal, USSR

3970. Swanson, S. A. V., and Ford, H., Stresses in thick-walled plane pipe bends, *J. Mech. Engng. Sci.* **1**, 2, 102-112, Sept. 1959.

Paper describes combined bending and internal pressure tests made on two 180° mild steel pipe bends. Cne was a 2.16-in. o d tube, 0.49-in. wall thickness bent to a radius of 6.5 ins. and the other 1.9-in. o d tube, 0.21-in. wall thickness bent to a radius of 6.0 ins. Both bends had 12 in. long integral tangent pipes and the bending load was applied to points on these tangent pipes, through steel balls to minimize end fixing moments, by a 50-ton Deneson testing machine. Internal pressure was applied from a 1000-atm maximum pressure Cook hand-pump using liquid paraffin as the fluid. Strain gages were bonded internally and externally at the central cross section of the bend. The method of internal bonding described in the paper is of interest as is the effects of pressure on the gages. The use of liquid paraffin B. P. eliminated the need for complicated waterproofing of the internal strain gages. Bending loads up to 1 ton and pressures up to 400 atms were applied.

The results are compared with the various theories which are commonly in use for calculating flexibility and stresses in thinner-walled pipe bends. It is concluded that either Turner & Fords or Barthelemy's theory give satisfactory agreement with the measured bending stresses and Thuloup's theory with modifications (described in appendix) gives good agreement, for simply flattened pipe, with internal pressure stresses. It is pointed out that random shape variations can lead to large errors in calculating stresses, and that combined bending and pressure loadings may increase or decrease the maximum stresses. A list of references is given which covers most of the presently used theories but no reference is made to any of the codes for pressure piping.

A. F. W. Langford, So. Australia

Material Test Techniques

(See Revs. 3929, 3957, 3960, 3968, 3982, 3983, 3988, 4015, 4344)

Properties of Engineering Materials

(See also Revs. 3848, 3850, 3852, 3859, 3866, 3946, 3952, 3957, 3958, 3959, 3960, 4015, 4016, 4197, 4198, 4261, 4262, 4381)

Book—3971. Jastrzebski, Z. D., Nature and properties of engineering materials, New York, John Wiley & Sons, Inc., 1959, xvii + 571 pp. $11.

This book presents a comprehensive coverage of the fundamental nature of materials, starting with the concepts derived from solid state physics and developing the phenomenological aspects of the behavior of materials from an engineering viewpoint. It is intended primarily as a text for basic courses in engineering materials and requires a previous knowledge of general chemistry, physics, and some calculus; it would be equally useful for practicing engineers who need a reference work to basic ideas of the behavior of all classes of materials.

The first three chapters consider fundamental concepts of interatomic and intermolecular forces and their relationships to the structural characteristics of crystal lime, high polymer, colloidal, and amorphous materials. In Chapter 3, concise discussions are included of such phenomena as diffusion, crystal growth, phase transformation, phase equilibria, and effect of heat treatment. The subsequent chapters consider specific characteristic properties and uses of all types of engineering materials under various environmental conditions. The author includes a wider variety of information and coverage than is usually included in a text of this type. For example, chapter headings include: ceramic materials, electrical and magnetic properties, thermal properties, corrosion, friction wear and lubrication, cementing materials, concrete and protective materials as well as the usual mechanical properties and characteristics of ferrous and nonferrous metals, etc. In general, the author has done an excellent job of condensing and presenting in a concise fashion many specialized facets of the field of materials behavior with a good appreciation for relative importance of the influencing parameters and a broad coverage of the environmental and microstructural factors.

Some readers may feel that certain specific topics are not given enough emphasis or that others could well be omitted. In the opinion of this reviewer, the book makes a valuable contribution to a unified picture of the whole field of engineering materials. Very few quantitative values are quoted; the text emphasizes primarily the qualitative aspects and concepts of relative behavior of different classes of materials under different conditions of service. At the end of each chapter the author has added a set of references and a number of well-phrased pertinent questions for more intensive study and review by the student.

From the engineering viewpoint perhaps too much emphasis is placed on the structure of matter in the first three chapters since only occasional use is made of this material in the later chapters on engineering behavior of materials. Also the topical coverage is probably somewhat more extensive than can usually be covered in a single undergraduate course. Nevertheless, the book should fill a long felt need for a modern factual and exceptionally well-written book of broader scope and understanding than most texts available today. The student can omit those sections not of immediate interest or defer for later study those specialized topics that are only occasionally encountered in engineering practice. In general, this is a remarkably fine book that will do much to help correlate the concepts of behavior of materials as observed by the physicist, metallurgist, and the engineer. T. J. Dolan, USA

3972. Ashkenazi, A. K., On the problem of strength anisotropy of construction materials; *Soviet Phys.-Tech. Phys.* **4**, 3, 333–338, Sept. 1959. (Translation of *Zh. Tekh. Fiz.* **29**, 3, 374–381, Mar. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author presents mathematical relations which permit determination of the strength in any direction of an anisotropic material with known, experimentally determined, strength in several basic directions. It is considered suitable to use a strength tensor of fourth order for anisotropic metallic materials, such as was used earlier for wood materials. Given relations apply to simple tension or compression and to shear.

Author compares theoretical and experimental strength values for different angles between direction of stress and grain direction—for rolled metallic materials, plywood, pine wood, two rolled aluminum alloys, and straight and cross rolled steel. He finds fairly close agreement. If strength properties along and across grain (or rolling) direction differ little, the diagonal direction corresponds to extreme strength values; that is, to maximum of shearing strength and minimum of tensile strength. As the anisotropy increases, extreme values no longer coincide with diagonal direction. For very great degree of anisotropy, extremum coincides with direction of texture orientation or direction transverse to it.

It is claimed that equal strength characteristics along and across direction of texture are not an indication of isotropy; in any direction strength can be considerably lower and unfavorably influence the general strength of the structure.

E. R. Steneroth, Sweden

3973. Fisher, D. H., Carlson, R. L., and Lankford, W. T., The effects of strain rate and temper rolling on the strain-aging characteristics of rimmed, deep-drawing steel, *Proc. Amer. Soc. Test. Mat.* **58**, 932–942, 1958.

The experimental studies reported here investigated the effects of strain rate and temper rolling on the strain-aging characteristics of a rimmed deep-drawing steel. All test material was obtained from 20-gauge sheet sheared from a single coil. Curves are presented to indicate the variation of the mechanical properties with strain rate, amount of temper rolling and aging time. They are discussed in terms of the history of the specimens and the strain rate, and correlated to yield point phenomena, work-hardening characteristics and elongation. Emphasis is also directed toward relating the observed behavior to the mechanics of plastic flow.

S. K. Ghaswala, India

3974. Lubahn, J. D., Hysteresis and anelasticity in cold-worked stainless steel, *Proc. Amer. Soc. Test. Mat.* **58**, 971–985, 1958.

Paper describes tests carried out to investigate the characteristics of room-temperature hysteresis in cold-worked 12% chromium stainless steel, 0.505-in. diam, threaded-end bar, type 403, quenched and tempered to 80,000 psi yield strength and stress-relieved at 1175° F. Actual nature of loading is described, and analysis of test results discussed, and the practical significance of hysteresis as a possible source of damping is brought out. Conclusions reached are that characteristics of hysteresis in cold-worked metals are different from those expected from anelastic theory, in that the time constants for creep and cyclic loading are inconsistent with each other by at least a factor of 30, and that the hysteresis is not frequency-dependent and that its loop is asymmetrical in shape. It is also noticed that the apparent modulus after cold work is much nearer the initial modulus than predicted by anelastic theory. If the minimum and maximum loads are held constant, there should be anelastic strain, which is somehow not observed. Thus appreciable investigation appears necessary to reconsider the concepts of hysteresis in cold-worked metals. S. K. Ghaswala, India

3975. Golubkov, A. I., and Panov, V. M., The delay in the yielding of steel under dynamic loading, *Indust. Lab.* **25**, 2, 220–221, Mar. 1960. (Translation of *Zavod. Lab., USSR* **25**, 2, 209–210, Feb. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

3976. Mathauser, E. E., and Pride, R. A., Compressive strength of stainless-steel sandwiches at elevated temperatures, NASA Memo 6-2-59L, 50 pp., June 1959.

Experimental results are presented from crippling tests of specimens in the temperature range from 80 F to 1200 F. The specimens included resistance-welded 17-7 PH stainless-steel sandwiches with single-corrugated cores, type 301 stainless-steel sandwiches with double-corrugated cores, and brazed 17-7 PH stainless-steel sandwiches with honeycomb cores. The experimental strengths are compared with predicted buckling and crippling strengths. Photographs of some of the tested specimens are included to show the modes of failure.

From authors' summary

3977. Livshits, L. S., and Rakhmanov, A. S., On the determination of the impact strength of steel at low temperatures, *Indust. Lab.* **24**, 5, 701–704, June 1959. (Translation of *Zavod. Lab., SSSR* **24**, 5, 622–625, May 1958 by Instrument Society of America, Pittsburgh, Pa.)

A method is described which makes possible an approximate evaluation of the energy spent on fracturing the specimen during the determination of the impact strength. The method makes it possible to estimate the safe temperature range for a given steel, and provides a means for determining specifications for the impact strength of steel at low temperatures.

From authors' summary

3978. Luce, W. A., and Peacock, J. H., Stainless steels and other ferrous alloys, *Indust. Engng. Chem.* **51**, 9 (Part 2), 1215–1222, Sept. 1959.

3979. Clayton-Cave, J., and Ineson, E., The mechanical properties of hardened high-speed tool steels—A review of methods of determination, *J. Iron Steel Inst., Lond.* **192**, 3, 248–253, July 1959.

3980. Kuenzi, E. W., Mechanical properties of some heat-resistant metal honeycomb cores, For. Prod. Lab., U. S. Dept. Agric., Rep. 1872, 28 pp., Dec. 1959.

This report presents the results of tests of commercially produced heat-resistant metal honeycomb cores for use in structural sandwich construction. Cores tested were made of four corrosion-resistant steels, a nickel-chromium alloy, and titanium. Properties evaluated were compressive strength at normal and elevated temperatures and shear properties at normal temperatures. Detailed descriptions of core materials and testing procedures are given.

From author's summary

3981. Freche, J. C., and Waters, W. J., Exploratory investigation of advanced-temperature nickel-base alloys, NASA Memo 4-13-59E, 39 pp., May 1959.

A series of nickel-base alloys that do not require vacuum melting techniques and that generally provide good stress-rupture and impact properties was developed for possible aircraft-turbine-blade or space-vehicle applications. The strongest composition displayed stress-rupture lives of 384 and 574 hours in the as-cast and homogenized conditions, respectively, at 1800 F and 15,000 psi. Several of the compositions evolved could not be broken in a low-capacity Izod impact tester.

From authors' summary

3982. Clapper, R. B., Isochronous stress-strain curves for some magnesium alloys, showing the effects of varying exposure times on their creep resistance, *Proc. Amer. Soc. Test. Mat.* **58**, 812–825, 1958.

The effect of soaking time (5 sec to 3 hr) on short-time creep resistance of elevated-temperature magnesium alloys sheet HK31A-H24 and HM21A-T8 and extrusion HM31xA-F is presented as isochronous stress-strain curves. The short-time creep resistance is equal or better after shorter than longer soaking time for 0.5% total extension. Within the range tested, heating and strain rates do not significantly affect 400, 500 and 600 F short-time creep strength of HK31A-H24 sheet, and strain-rate variations have no significant effect on 700 F short-time creep strength of HM21A-T8 sheet.

J. Koziarski, USA

3983. Weissmann, G. F., and Babington, W., A high damping magnesium alloy for missile applications, *Proc. Amer. Soc. Test. Mat.* **58**, 869–892, 1958.

Author states: "Resonant amplitudes and accelerations are of considerable importance for the proper functioning of electronic components of guided missiles. These accelerations can be substantially reduced if the exciting forces are kept low. This can frequently be attained by selecting structural materials with sufficiently high internal damping, that is, materials which will absorb a high percentage of the excited vibrational energy. The unusually high damping capacity of certain magnesium alloys has been recognized for some time.

"A new binary alloy of magnesium plus 0.6% zirconium was developed, called K1X1. The finer grain size of K1X1 results in higher strength and ductility and considerably reduces problems related to casting and fabrication. It also shows higher values for both yield strength and tensile strength at higher rates of strain."

The tests are described in detail and numerous numerical results are tabulated and graphed.

C. E. Balleisen, USA

3984. Znamensky, E. M., An investigation of the impact strength of wood (in Russian), Issledovaniya prochnosti i deformationisti drevesinyi, Moscow, Gos. Izd-vo. Lit. po Str-vu i Arkhitekt., 1956, 141–157; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10657.

Investigations are described of the transverse bending of two series of standard samples of clear timber; pine in the first case, pine and fir in the second series.

Using electronic instruments and electrical strain gages, the author has been successful in recording the strain values and dynamic (impact) strength of a wood sample and plotting the curve of impact strength. It is found that the speed of reaction of wood samples is linearly related to the speed of impact, and the reaction pressure does not set up any additional bending stresses.

A clearly-marked region of inelastic strain has been found to exist, coupled with a perceptible increase (compared with the static value) in the reduced value of the modulus of elasticity. In some cases, the rate of strain of the wood under load has noticeably influenced its stress and strain characteristics.

V. F. Ivanov

Courtesy Referativnyi Zhurnal, USSR

3985. Palmour, H., III, Kriegel, W. W., DuPlessis, J. J., and Harrell, G. O., Selected abstracts on the mechanical behavior of ceramics, North Carolina State College, Engng. School Bull. 73, 151 pp., July 1959.

3986. Scofield, F., Protective coatings, *Indust. Engng. Chem.* **51**, 9 (Part 2), 1213–1214, Sept. 1959.

3987. Zel'dovich, Ia. B., Kormer, S. B., Sinitsyn, M. V., and Kuriapin, A. I., Temperature and specific heat of plexiglas under

shock wave compression, *Soviet Phys.-Doklady* **3**, 5, 938–939, May 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **122**, 1, 48–50, Sept. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

3988. Findley, W. N., and Peterson, D. B., Prediction of long-time creep with ten-year creep data on four plastic laminates, *Proc. Amer. Soc. Test. Mat.* **58**, 841–861, 1958.

The object of this study was the determination of the creep behavior of plastic laminates at constant stresses, at constant temperature of 77 ±1 F and relative humidity of 55 ±2% up to 100,000 hr and the comparison of the creep data with different creep theories. The materials investigated were grade C canvas laminate, parallel and cross-laminated paper laminate and asbestos laminate. The creep strains during these long-time tests were in some cases influenced by failures in the air-conditioning system, by the aging of the materials and the occurrence of uncontrollable shocks in the equipment causing slippage of the extensometer. A few tests were also made to determine the magnitude of strains both for recovery and for creep on reloading. The creep curves of the main investigation could be represented reasonably well by the equation: $\varepsilon = \varepsilon_0 + m \cdot t^n$, where ε is the strain, t is time and n is a stress-independent constant; the stress dependence of the constants ε_0 and m have been evaluated in terms of hyperbolic sine functions. M. Hempel, Germany

3989. Sidorovich, A. V., Vashchenko, V. S., and Kuvshinskii, E. V., Determination of the softening temperature of polymer films by means of measuring the thermo-mechanical curves under uniaxial stress, *Soviet Phys.-Tech. Phys.* **4**, 4, 457–464, Oct. 1959. (Translation of *Zh. Tekh. Fiz., USSR* **29**, 4, 514–523, Apr. 1959 by American Institute of Physics, New York, N. Y.)

This article describes an instrument for determining the softening temperature of polymer films by the method of thermomechanical curves. The thermomechanical properties of polymethyl methacrylate, polystyrene, styroflex and other materials are studied. Using styroflex as an example, it is shown that there is a great difference between the thermomechanical curves for oriented and nonoriented materials.

From authors' summary

3990. Beer, F., The behavior of fibre-reinforced plastics under bending stress (in German), *ZVDI* **101**, 22, 1045–1050, Aug. 1959.

If plastic components reinforced by unidirectional fibers to withstand bending stresses are subjected to shear strains then a danger arises in that the critical shear stress of the bond is less than the tensile and compression strength increased by the reinforcement. A simple method has been developed to calculate this shear strain—which is frequently neglected in the case of isotropic material.

Additional reinforcement through fibers located crosswise is recommended to absorb high shear strain.

From author's summary

3991. Becker, G. W., The dynamic-elastic behavior of foamed plastics (in German), *Acustica* **9**, 3, 135–143, 1959.

Different methods are described for determining the dynamic Young's and dynamic shear moduli of foamed plastics in the range 0.1 to 100 c/s—for harder substances up to 1000 c/s. In estimating the elastic modulus on short cylindrical probes with attached end surfaces the influence of the shape of the probe for given Poisson's ratio is considered theoretically and tested experimentally. The results obtained on a series of different materials can be explained in terms of a simple model for closed and open mesh foamed material.

From author's summary

3992. Seymour, R. B., Plastic, *Indust. Engng. Chem.* **51**, 9 (Part 2), 1204–1212, Sept. 1959.

Structures: Simple

(See also Revs. 3875, 3884, 3892, 3897, 4015, 4016)

Book—3993. Urquhart, L. C., O'Rourke, C. E., and Winter, G., Design of concrete structures, 6th ed., New York, McGraw-Hill Book Co., Inc., 1958, ix + 546 pp. $8.

As authors say in the Preface "This edition, like its predecessors, aims to give sufficient development of the theory of concrete design with illustrative examples to ensure the beginner a thorough understanding of the fundamentals."

In a very simple way are treated the following subjects: Section 1: Plain concrete; Sec. 2: General properties of reinforced concrete; Sec. 3: Beams and slabs; Sec. 4: Columns; Sec. 5: Bending and axial stress; Sec. 6: Continuous beams and frames; Sec. 7: Footings; Sec. 8: Reinforced concrete buildings; Sec. 9: Retaining walls; Sec. 10: Arches; Sec. 11: Slab, beam and girder bridges; Sec. 12: Ultimate strength design (this is a new section); Sec. 13: Prestressed concreate. There are also five appendices with codes, tables, diagrams and graphs.

The appearance of this sixth edition proves that the book fills the scope of its authors. A. J. Bignoli, Argentina

3994. Magini, O., Practical solution of a reinforced concrete continuous beam (in Italian), *Atti Ist. Sci. Costr., Univ. Pisa Pub.* 69, 24 pp., 1959.

3995. Bannister, A., The use of substitute frames in the determination of influence lines for moments in rigid frames, Parts 1 and 2, *Civ. Engng., Lond.* **54**, 637, 875–877, July/Aug. 1959; **54**, 638, 1037–1040, Sept. 1959.

Moment influence lines are established by introducing an internal angle change (starting with the corresponding fixed-end moments), and using Maxwell's reciprocal relationship. The resulting moments, including sway effects, are established by moment distribution, using the English "no-shear" approach for single-bay symmetrical frames (which is similar to Grinter-Tsao cantilever moment distribution in USA) as an approximation of the sidesway action of multibay frames. This approximate solution is then corrected by a successive approximation method of adding balancing shears for further distributions. Vertical joint movements are handled separately from horizontal movements, a process which seems to be limited to a symmetrical system of vertical deflections. P. M. Ferguson, USA

3996. Dean, D. L., and Tauber, S., Solutions for one-dimensional structural lattices, *Proc. Amer. Soc. Civ. Engrs.* **85**, EM 4 (*J. Engng. Mech. Div.*), 31–41, Oct. 1959.

The use of difference equations in obtaining closed form solutions to special type structural analysis problems is presented. To illustrate the method, authors have chosen a rectangular and a triangulated Vierendeel truss with n panels, for which complete solutions are offered. The method can be successfully used in structural lattices, i.e., systems consisting of a large number of members, which have properties varying in a regular manner.

J. D. Marketos, USA

3997. Heyman, J., On the absolute minimum weight design of framed structures, *Quart. J. Mech. Appl. Math.* **12**, 3, 314–324, Aug. 1959.

Author extends general theorem developed by Drucker and Shield which applies to plastic structures to one valid for both elastic and plastic beams and frames. Proof is by energy. Author shows application to simple design and develops a relaxation method for continuous beams and frames. Numerical example of a continuous beam is given. Finally, weight of normal designs for fixed ended beam are compared to that obtained by absolute minimum weight.

Problem has intrigued many for some time but has had little practical application since all work deals with stationary loads. It would be of interest and might lead to usage if method were applied to moving loads and if effect of shear were included.

K. H. Lenzen, USA

3998. Fuxa, U., Remarks and suggestions regarding the calculation of systems composed of stiffly jointed members (Frame works and trusses in general) (in Italian), *G. Gen. Civ.* **97**, 2/3, 144–149, Feb./Mar. 1959.

3999. Habel, A., The critical length of frame members of reinforced concrete (in German), *Beton u. Stahlbeton.* **53**, 11, 273–275, Nov. 1958.

After reviewing general buckling concepts for steel and reinforced-concrete structures and bars, the possibility of applying approximate formulas with $E = cte$ to the case of concrete frames is investigated. The author (well known by his publications in this field: title source **50**, 12, 305–307, 1955; **51**, 7, 155–159, 1956; this paper; **54**, 2, 25–31, 1959] finishes by discussing criteria for the bending moment which should be used in those formulas.

E. P. Villarreal, Argentina

4000. Popov, I. G., The design and calculation of frame and panel buildings (in Russian), *Byul. Tekhn. Inform. Glavleningradstroy* no. 9, 21–25, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10508.

An investigation of the wind-load distribution between the transverse frame bents and the vertical stiffening panels, or walls of frame-and-panel buildings. The usual calculation scheme is criticized, in which only the horizontal forces of interaction between the framing and the walls are considered, determined from the condition of equal horizontal displacements of reciprocally-linked points. It is suggested that the vertical interaction forces between the frame joints and the connected outer edges of the walls also be considered with allowance for the longitudinal strains in the frame legs (columns). A specimen calculation is used to demonstrate that the horizontal interactions obtained by the author's method of calculation have equal signs in all storeys, while by the method he criticizes, the sign becomes reversed in the upper storeys; there is an error in the calculation of the explanatory example.

Ya. B. L'vin

Courtesy Referativnyi Zhurnal, USSR

4001. Csonka, P., Procedure for evaluation of trial loads on floors (in German), *Bautechnik* **35**, 10, 396–399, Oct. 1958.

Author investigates influence of distribution of uniformly distributed loading on part of simply supported floor to be employed when deflections of loaded and *nonloaded* parts are not available. Theory, based on a previous paper by author in same source (March 1958), assumes that an infinite number of beams exists at both sides of the loaded part, the individual T-shaped sections being connected by hinges; another solution for an orthotropic slab is envisaged by author. Difference equation for intermediate links between adjacent beams is solved by a Fourier series and various loading cases along lines of assumed hinges are investigated. Deflection of adjacent nonloaded parts and thus their contribution on load distribution is computed. For a sinus-shaped loading along a line of hinges three possibilities occur. Either the deflection extends over a great number of adjacent beams, increasing symmetrically from both sides in a curved shape with a maximum under the load, or the two adjacent bays only take part or a zig-zag line of alternately negative and positive gradually decreasing deflections occurs at both sides of the loaded line of hinge. Another case deals with a uniformly distributed load along a hinge. Each loading for two adjacent beams must be investigated separately if load extends over several beams. Numerical example of a practical case to ascertain the carrying capacity of a floor construction by loading test over part is included.

P. W. Abeles, England

4002. Korenev, B. G., Starting resonance (in Russian), Researches on the dynamics of structures, Moscow., Gos. Izdat. Lit. Str-vu i Arkhitekt., 1957, 162–183; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9507.

The Van-der-Pol method is used to investigate the constrained vibrations of a system with one degree of freedom in cases where the amplitude and frequency of the constraining force are time-variable after particular laws.

The influence of the fading of vibrations is also investigated according to the hypothesis of E. S. Sorokin (in "Researches on the dynamics of structures" Moscow, Gos. Izdat. Lit. Str-vu i Arkhitekt, 1951).

Cases are also examined of changing amplitude of the constraining force by an exponential law and a power series on the condition that the frequency of the constraining force varies proportionally with time, as well as cases in which the frequency of the constraining force is either a power function or a trigonometrical function of time.

The solutions of nearly all the problems are given in closed form.

N. V. Butenin

Courtesy Referativnyi Zhurnal, USSR

4003. Fedorkov, G. V., The decay of free oscillation of systems with multiple degrees of freedom (in Russian), *Trudi Mosk. In-ta Inzh. Zh.-d. Transp.* no. 91, 132–142, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10321.

The problem is presented as a particular case of the general problem of calculating the constrained oscillations of elastic systems with multiple degrees of freedom in the presence of hysteresis losses (cf. E. S. Sorokin, "Researches on the dynamics of structures," Stroyizdat, 1951; G. S. Pisarenko, "The oscillations of elastic systems in the presence of dissipation of energy in the material," Kiev, Izd-yo Akad. Nauk USSR, 1955). The solution of the oscillation equation is obtained in matrix form. It is concluded that the rate of decay of the oscillations is determined only by the diagonal elements of the matrix of dissipation, and that the influence of the collateral elements is evidenced only by a change in the form of the oscillation. The dissipation of the energy of oscillation is calculated on the assumption of the presence of viscous friction.

V. V. Khil'chevskii

Courtesy Referativnyi Zhurnal, USSR

4004. Kisseleva, I. V., The problem of the development of the method of displacements in the dynamic theory of structures (in Russian), *Trudi Mosk. Avtomob.-dor. In-ta* no. 20, 241–246, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10326.

Starting from the equation of the deflected axis of a beam under vibratory load, expressions are derived for the dynamic reactions of the bars arising in vibrational deflection of the supports, making allowance for the weight of the bars. The equations are set up for different boundary conditions and different types of displacement or deflection of the supports.

P. A. Lukash

Courtesy Referativnyi Zhurnal, USSR

4005. Cervi, S., Influence of the prestressing of the piers of hyperstatic portals (in Italian), *G. Gen. Civ.* **97**, 6, 482–485, June 1959.

Structures: Composite

(See also Revs. 3962, 3993, 4185, 4294)

4006. Boroditch, M. K., The analysis of composite (steel and reinforced concrete) bridges under vertical load by the concrete

strength (in Russian), *Trudi Belorussk. In-ta Inzh. Zh.-d. Transp.* no. 1, 130–139, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10504.

Author is of the opinion that the assumption usually made in strength calculations of a 10:15 ratio between the moduli of the steel and the concrete does not correspond to the real conditions, and needs to be more accurately defined as suggested by the TU project. However, the method of calculation adopted in that project leads to increased structural weight, and consequently requires correction terms to be introduced. In the strength analysis of concrete slabs, the author suggests: (1) to standardize not the allowable stresses, but the allowable fiber strains in the concrete; (2) to specify the modulus ratio m according to the grade of concrete to be used.

M. M. Manukyan
Courtesy Referativnyi Zhurnal, USSR

4007. Konishi, S., and Nakamura, H., An example of the measured loads on the wheelset, *Bull. JSME* **2,** 8, 526–532, Nov. 1959.

An experimental test of the loads on the wheel passing a curved track—lateral, vertical, and longitudinal loads—was carried out for the new B-B-B diesel electric locomotive of type DF 50. The results are as follows:

(1) Lateral load: For the leading axle, the lateral loads act from outside toward center of the wheelset for both wheels. As for the inside wheel, the load is nearly independent of the curvature of track while, for the outer one, it increases as the radius of curve diminishes, attaining a maximum value of 5.6 tons (lateral load/vertical load = 0.7) for 200-m radius.

On the other hand, for the trailing axle, the loads are very small with indefinite directions of action.

(2) Vertical load: The vertical loads generally agree with the theoretical values, calculated considering the centrifugal force.

(3) Longitudinal load: While the longitudinal load has been hitherto rarely treated theoretically, considerable loads were revealed, attaining a maximum value of 1.9 tons. The direction of loads is forward for the outer wheel of the leading axle and the inside wheel of the trailing one, and backward for the remainder.

From authors' summary

4008. Groisman, S. Kh., The calculation of multiply-cross braced decks by Prof. A. I. Segal's method (in Russian), *Trudi Mosk. Tekhn. In-ta Rybn. Promsti i Kh-va* no. 8, 140–141, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9205.

It is demonstrated that the calculation of decks with a number of cross braces can be more simply performed than by solving the nonlinear system of equations proposed by A. I. Segal; author suggests solving one fourth-order equation, and a system of linear equations.

N. K. Snitko
Courtesy Referativnyi Zhurnal, USSR

4009. Smolyakov, B. N., The strength of riveted and welded ship hull structures (in Russian), *Trudi Gor'kovsk. In-ta Inzh. Vodn. Transp.* no. 14, 25–49, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9240.

Model test data are used to plot a curve of coefficients of efficiency of ship structures, representing the ratio of the cross-sectional area of the riveted portion of the structure to the total cross-sectional area of the model, which had double-riveted butt joints. The models were tested to destruction in tension. Author recommends multiplying the allowable stress values for the all-welded hull by this coefficient, and taking these reduced values as the allowable stresses for a riveted hull, reinforced by welded stiffeners. Author's conclusions lack conviction, since the strength of the structure will be destroyed by compression, with consequent loss of stability. The theoretical arguments of the author, based on analysis of the form of construction investigated by him, are inconclusive.

A. A. Kurdyumov
Courtesy Referativnyi Zhurnal, USSR

Machine Elements and Machine Design

(See also Revs. 3793, 3795, 3796, 3824, 3825, 3911, 3912, 3914, 3917, 3918, 3928, 3958, 4017, 4154, 4379)

Book—4010. Slaymaker, R. R., Mechanical design and analysis, New York, John Wiley & Sons, Inc., 1959, xiii + 418 pp. $9.50.

This text is evidently the result of author's considerable experience as a design engineer and as a teacher of machine design. Its major difference from existing texts lies in its use of what might be called the "case method" of presentation. Theory is presented as is needed for the particular designs which are discussed. The design problems are ones which have actually arisen in industry and are so identified. The organization and presentation of material is quite good.

The first part of the book contains general material on limit dimensioning, materials and processes, cyclic loads, stress concentrations, factors of safety and working stresses. This material is fairly standard but is reasonably up-to-date and is given in the first quarter of the book. The remainder of the book is given over to the presentation of 21 design projects, together with the necessary theory, as follows:

1. A layout problem for a drive shaft.
2. Approximate stress analysis and design of a four-bar linkage.
5. Design of a hand crank.
7. Drive shaft design for an impact extrusion press.
8. Critical speed of a shaft assembly. (Solution is by use of the Rayleigh equation.)
9. Leaf spring design.
10. Helical spring design.
11. Bearing cap bolts for a connecting rod.
12. Column design.
13. Metal-clad rubber bushings.
14. Sleeve bearing design.
15. Needle bearings and planetary gear trains.
16, 17, 18, 19. Gear designs.
20. Air brake design.
21. Belt drive for a compressor.

Reviewer believes the general theoretical level and treatment of this book will be considered inadequate by many teachers of design. The Hencky-von Mises theory of material failure is not given, for example. In the discussion of columns author states that "Because no completely satisfactory rational solution has been evolved for elastically stable (short) columns, design engineers have resorted to an empirical equation proposed by J. B. Johnson." Reviewer believes that most engineers would agree that the tangent modulus theory of Engesser-Considère is rational and that the various empirical relations are valid only as they correlate with the results of the tangent modulus theory. Many engineers will not like author's use of the "psuedo-stress" in defining factor of safety for a column.

W. J. Carter, USA

Book—4011. Nevzglyadov, V. G., Theoretical mechanics [Teoretichskaya mekhanika], Moscow, Gosudarstvennoe Izdatel'stvo Fiziko-Matematicheskoi Literatury, 1959, 584 pp. 11r 65k.

This new work differs in several respects from the existing comparatively simple textbooks on theoretical mechanics.

Having its origin in the author's lectures at the University of Leningrad and being directed to students on the physical faculties of the Russian universities, the book presupposes considerable mathematical knowledge not only of the calculus, but also of the field of partial differential equations and of calculus of variations.

Divided into two main parts, the work in question covers the

whole field of classical mechanics. First comes the treatment of a material point, of systems of points and of a rigid body. The second main part is devoted to the mechanics of continuous media.

There are altogether five sections in the first and two sections in the second main part of the book. The subject headings will give a more detailed idea of the material involved.

Section I, namely Mechanics of a material point, has 5 chapters with 37 subtopics. Chapter 1 on kinematics of a single material point is followed by general laws of its dynamics, then come considerations of central forces, theory of small vibrations and a fine discussion of motions under constraints.

Section II deals in its two chapters and 21 subtopics with the dynamics of a system of points. It opens with the general theorems, whereas the second chapter is devoted to a detailed far-reaching theory of motions with constraints.

Section III is divided into 3 chapters with 16 paragraphs. Beginning with kinematics of a rigid body, it continues over a short chapter on kinematics of relative motion of a single point to the dynamics of relative motions.

The following section is a systematic exposition in the dynamics of a rigid body and of bodies with variable mass. It contains three chapters and 22 subtopics. The first chapter brings a remarkably exact treatment of dynamics of rigid bodies, then come two paragraphs on impact and the last chapter is devoted to bodies having variable mass and, in connection therewith, to some questions on rocket flight.

The first main part of the book concludes with an attractive section on small oscillations and on the fundamental principles of analytical mechanics. It has 5 chapters and 28 subtopics constituting, without any doubt, the most valuable part of the work. Two chapters are devoted to small oscillations about the stable equilibrium and about the state of stable motion; the remaining three chapters deal in a highly scientific manner with variational principles of mechanics, with the Hamilton-Jacobi theory, with integral invariants and canonic transformations.

A section on the general equations of the mechanics of continuous media with three chapters and 30 subtopics forms the beginning of the second main part of the book. Chapter on kinematics is followed by a beautiful derivation of the general equations of dynamics and by a short exposition of the theory of an isotropic absolutely elastic body.

The last section, VII, deals in its three chapters and 18 subtopics with the fundamental facts on hydrodynamics. First comes a chapter on ideal liquids, then the treatment of viscous fluids, and the work concludes with an exposition from the theory of turbulence.

Reviewer considers this book to be one of the best in the field of theoretical mechanics.

V. Vodicka, Czechoslovakia

4012. Anonov, G. D., Determination of the positions of a three-dimensional, quintuply-linked, crank-connecting rod mechanism (in Russian), *Sb. Nauchn. Trudi Kafedr. Mat. Mekh., Khimii, Leningrad. In-ta Tochnor Mekhanika i Optiki* no. 24, 71–90, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8435.

A graphical analytical method is described for plotting the positions of a three-dimensional, quintuply-linked, crank-connecting rod mechanism, representing a development of graphical constructions presented earlier by the same author. First, a number of positions of the mechanism must be determined; any intermediate positions (and consequently the kinematic diagrams) can be obtained by Newtonian interpolation, applying the method of successive approximations and linearizing small segments of the curve.

V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR

4013. Yao, C.-N., The classical equations of the strength of elastically-supported chains and some results of their analysis (in Chinese), *Trudi Kharbinsk., Politekhn. In-ta, Khaerbin, Gun-e Dasui Suibao* no. 3, 84–97, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9259.

General equations are given for the strength analysis of multiple-span, elastically-supported chains in the presence of a variable longitudinal force, the moment at the joint being represented by the product of the angle of rotation by the area of the curve of longitudinal forces. The original solutions by a number of Soviet authors are quoted.

N. K. Snitko

Courtesy Referativnyi Zhurnal, USSR

4014. Cherenin, V. P., Symbolic representation of planetary and differential mechanisms (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 35–43, Jan. 1958.

The general theory of selection of the scheme of planetary and differential drives was first worked out by M. A. Kreines in his doctoral dissertation in 1943, and subsequently developed by Kreines, Rozovsky and the author. From the symbolic representation *S* introduced by Kreines it became possible to get a whole line of various symbolic representations. Since such representations may be obtained in advance by using the elements of combinatorical algebra, the first steps in the synthesis can be reduced to the selection and investigation of symbolic representation in accordance with any given conditions.

In this article the most used drives with one and two degrees of freedom are treated. By means of symbolic representation the arrangement, kinematics and mechanical advantages of complex planetary and differential mechanism are described in the same simple manner as plain gear mechanisms consisting of chains with fixed axes of rotation. This permits not only the simplification in the choice of the arrangements of the links by starting from the transfer of the ratio of the separate three-link mechanism, but by taking into consideration at once the mechanical advantages and the conditions of distribution of the chains in space. The same is derived also for noncoaxial mechanisms.

From author's summary by M. Maletz, USA

Fastening and Joining Methods

Book—4015. Sudasch, E., Welding technology [Schweisstechnik], 2nd ed., Munchen, Carl Hanser Verlag, 1959, xiv + 798 pp. DM 65.

The main subject of this combined handbook and textbook is welding of steel and cast iron. Welding of Al alloys and magnesium, copper, zinc, lead, nickel and titanium are given a short description and welding of plastics and plexiglas are just mentioned.

The metallurgical processes in steel and cast-iron welding are described in detail, sufficient for all needs of designers and structural working engineers.

Electric arc welding, the main subject of the book, is described in chapters giving the metallurgical processes, the electric arc, equipment, workplace and electrodes. Welding of thin plate, heavy structures, cast iron, all sorts of steel from stainless steel to the usual mild steel, as well as specialties such as welding of hard metal to steel, are described. The welding equipment ranges from usual hand equipment to automats and bolt pistols.

A similar description is given of the autogeneous and gas-welding processes. Specialties such as Argonarc and electric resistance welding, etc. are all, as far as the reviewer can see, included in the book.

Design of welded steel structures is briefly mentioned, and the chapters dealing with weld stresses and calculation of welded connections will hardly give anything new to an experienced designer. Chapters dealing with testing and flame cutting will be of more interest. The book has a marked inclination to the metallurgical side of welding problems.

The equipment described is with few exceptions, of West German origin, and the book gives good information on the welding standard in West Germany. List of references contains 706 items which, with few exceptions, are references to German authors.

A. Selberg, Norway

4016. Kobler, J. S., Notch-ductile weld metal for dynamically loaded T-1 steel structures, *Welding J.* **39,** 4, 160s–171s, Apr. 1960.

Investigation leads to development of electrodes capable of producing weld deposits responding to a stress-relief anneal and exhibiting both static and dynamic properties equivalent to those of T-1 base metal. From author's summary

4017. Haake, H., Geometry of screw-thread flanks (in German), *Werkstattstechnik* **49,** 7, 376–385, July 1959.

The intersection curves between a plane parallel to screw axis and the flanks of cylindrical threads having a triangular basic profile and equal half-angles are hyperbolas with the two branches displaced axially with respect to each other and skewed by the thread lead. Author derives equations for these curves and analyzes the geometry of thread flanks of both external and internal threads. A precise and an approximate solution are presented for computing the wire and ball diameters and the measurements used for inspecting the effective pitch diameter of threads. The rake correction is included. Several tabulated computations using both solutions are given for single and multiple lead, external and internal, triangular and Acme threads.

Reviewer finds the subject to be presented quite methodically and well explained. The equations and the analysis introduced by the author are useful in geometric investigations on thread flanks and in computations required for accurate pitch-diameter measurements employing wires or balls.

A. A. Mittenbergs, USA

Rheology

(See Revs. 3848, 3849, 3940, 3971)

Hydraulics

(See also Revs. 4034, 4036, 4144, 4349, 4355, 4370, 4373)

4018. Oki, I., and Kawakami, K., Characteristics of disc valves in angle-valve type chambers (Experimental research on disc valves, 5th report), *Bull. JSME* **2,** 8, 644–650, Nov. 1959.

In an angle-valve-type valve box, specially prepared, a series of experiments were carried out on disk valves with flat- or conical-seat under a head of about two meters. Thus the relations between valve lift, discharge and lifting force were studied whereby many factors in the characteristics of disk valves under these conditions were made clear. From authors' summary

4019. Kovalev, F. Ya., The flow capacity of a bottom-discharge floodgate (in Russian), *Sb. Stud. Nauchn. Rabot. Belorussk. Politekhn. In-ta* no. 3, 92–95, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8734.

It is pointed out that the flow coefficients of a bottom-discharge floodgate working under a head of water, in the presence and absence of submergence on the lower side respectively, are not reciprocally equal, owing to the difference in values of the coefficient of resistance of the discharge. The author observes that, according to the results of his laboratory experiments for unsubmerged gates, the latter coefficient may be assumed equal to unity, independently of the nature of the discharge section of the gate (as is recommended in the literature). For submerged gates, on the other hand, this coefficient will depend on the nature of the section joining the gate to the tail-race. In experiments made in the presence of submergence of the gate, the measured values were within the limits of 0.47 to 0.88. Some experimental data are given on the manipulation of the sluice paddles of a flood-discharge standpipe. N. P. Rozanov

Courtesy Referativnyi Zhurnal, USSR

4020. Nikolaev, N. V., Ejector-spillways for recovery of power during flood (in Russian), *Gidrotekh. Stroit.* **27,** 1, 41–43, Jan. 1958.

Author suggests the use of ejector-spillways (e.s.). The mixing chamber of e.s. is connected with the space between impeller and draft tube. A theory of e.s. is given. Conclusions drawn from the model tests, performed to check the theory, are presented without detailing the experimental results. Some of these are: The e.s. ought to be dimensioned to double the turbine discharge at least; closing the draft tube downstream gives the best efficiency.

A. Verba, Hungary

4021. Timoshenko, Ya. V., Determination of velocity in tailwater of spillways (two-dimensional problem) (in Russian), *Gidrotekh. Stroit.* **28,** 2, 36–40, Feb. 1959.

Author tries to calculate velocities in the hydraulic jump by application of the theory of free turbulence. The length of hydraulic jump is divided into two zones. In the upsteam zone a core with constant velocity is assumed, being equal to the approach velocity V_0. The thickness of the core decreases with growth of boundary, developing both at the contact with the roller and at the bottom. In this zone V_0 represents also the maximum velocity, and the velocity distribution in the boundary layer follows Gauss's law of probability. In the downstream zone, completely occupied by the boundary layer, the maximum velocity decreases in the downstream direction; the velocity distribution is again assumed to follow Gauss's law of probability.

Author gives a system of equations for the velocity determination, with explicitly solved coefficients. The presented documentation is not sufficient to prove the proposed analytical solution. Comparisons affected by the reviewer with other measured data on the velocity distribution [Rouse, &..., *Proc. Amer. Soc. Civ. Engrs.* **84,** HY 1 (*J. Hydr. Div.*)] show great discrepancies. Despite this and some inconsistencies and uncertainties, the article is worth attention because in this field even rough approximations can be useful. Moreover, on the basis of further and more extensive experimentical material, the author's analytical approach could, probably, be used to obtain more accurate equations for the velocity distribution in the hydraulic jump.

M. M. Boreli, Yugoslavia

4022. Sur'yaninov, G. N., Hydraulics of multiple-arch spillways (in Russian), *Gidrotekh. Stroit.* **27,** 2, 42–44, Feb. 1958.

Spillways over arch dams were investigated until now only to determine the influence of the angle of the arch on the discharge and concerned only simple arch dams. Obtained formulas are not applicable to spillways on multi-arch dams because the influence of the following factors causes very specific hydraulic conditions:

(1) Multi-arch dams are inclined in the vertical plane;

(2) Arches are adjacent to each other;

(3) Their curvature is great.

An experimental research described by the author lead to a formula for the discharge coefficient, which takes into account the influence of the angle of inclination of arches, of central angle of arches, the conditions of approach, and the shape of the spillway crest. For each of these influences specific coefficients are determined by several formulas.

Reviewer believes that this research is a valuable contribution to the hydraulics of multi-arch spillways, and is presented in such

a form that it can be directly used in the design of this very advantageous, for some specific conditions of dam sites, type of dams.

B. S. Browzin, USA

4023. Antonnikov, A. F., Local increase of specific discharges in tailwaters of power plants and preventive measures against it (in Russian), *Gidrotekh. Stroit.* **27**, 2, 31-36, Feb. 1958.

It is known that specific discharges (discharges per unit of width, L^2T^{-1}) increase in some places on the length of the apron and downstream of it, causing scours, in cases when the width of the river bed increases. Experimental research was performed on two models of a spillway for a power plant which is in the design stage. The results of research on models were favorably compared with field observations on three other existing dams when scours take place. The scour is due in part to the local increase of specific discharges due to the transverse flows. To prevent it, the flow must be directed by local dividers which must spread the flow uniformly over the entire width.

The intensive transverse flow begins from the foot of the spillway and increases the specific discharge in the middle part of the spillway bay. The dividers prevent it. Several structural types of dividers were investigated and some of them recommended as the best. The dividers essentially improve the hydraulic conditions below spillways,

Reviewer concludes from experimental data of the paper that the decrease of specific discharges in the middle of the river at the downstream edge of the apron of a 300-meter wide (including piers) 14-bay spillway due to the dividers is almost twice (1.8). In some cases the flow at banks is backward, i.e. in upstream direction without dividers, and becomes downstream with them. The length of dividers is relatively short so that it is an inexpensive measure to improve hydraulic conditions.

Dam designers dealing with spillways and a spreading flow below the spillway may obtain valuable ideas and information from this paper for essential improvements of tailwater conditions by construction modifications to the traditional design.

B. S. Browzin, USA

4024. Teepaks, L. A., The hydraulic resistance of pipes in the subquadratic region (in Russian), *Trudi Tallinsk. Politekhn. In-ta* **A**, 83, 33 pp., 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8706.

The author points out that, while in the square-law region the resistance is characterized by a single quantity, the dimension of the absolute roughness Δ or the coefficient of (surface) roughness n, in the subquadratic region it is impossible to set up a single expression without introducing additional coefficients. It is demonstrated that in the subquadratic region the resistance can be suitably expressed by a relationship in the form

$$\frac{\varepsilon}{\gamma} = f\left(\frac{\Delta U_*}{\gamma}\right) \qquad [1]$$

From the evaluation of experimental data, author concludes that this relationship is linear, while the resistance in the subquadratic region is determined by the formula

$$\frac{1}{\sqrt{\lambda}} - 2\log\frac{r}{\Delta} = 0.7 + 2\log\frac{\Delta U_*/\gamma}{a + m\Delta U_*/\gamma},$$

in which ε is coefficient of virtual viscosity at the wall, γ coefficient of viscosity $U_* = \sqrt{gRi}$ dynamic viscosity. The values for the numerical coefficients a and m and the boundaries of the subquadratic region for pipes of different materials are given from evaluation of the experimental data of F. A. Shevelev, G. M. Murin, and others.

V. I. Gotovtsev

Courtesy Referativnyi Zhurnal, USSR

4025. McPherson, M. E., Generalized distribution network head loss characteristics, *Proc. Amer. Soc. Civ. Engrs.* **86,** HY 1 (*J. Hydr. Div.*), 75-91, Jan. 1960.

The analysis of complex distribution systems can be expedited by means of principles developed in the paper. Head losses over a wide range of demand and equalizing storage rates can be calculated directly, based on only two or three complete network analyses, under design assumptions employed in normal practice.

From author's summary

4026. Sangster, W. M., Wood, H. W., Smerdon, E. T., and Bossy, H. G., Pressure changes at open junctions in conduits, *Proc. Amer. Soc. Civ. Engrs.* **85,** HY 6 (*J. Hydr. Div.*), 13-42, June 1959.

Authors report the results of theoretical and experimental studies performed on pressure changes in conduits flowing full. The measured value is the pressure instead of the head.

The system under study consists of three pipes placed in the form of a T, two perpendicular pipes providing the necessary supply. All the results are given with dimensionless coefficients and the values referred to are the mean velocity head and the flow in the downstream pipe.

Many experiments have been performed on four sizes of lucite pipes, with junction boxes of different shapes (rectangular, square and round) and sizes. The influence of deflecting devices has been systematically observed, also.

The results obtained by a very simple theoretical study—when it was possible—are in good agreement with the experimental data.

L. Escande, France

4027. Popov, Yu. N., The hydrodynamic moment of bodies travelling under the free surface of a perfect fluid (in Russian), *Trudi Leningrad Korablestroit. In-ta* no. 18, 111-123, 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8660.

Author determines hydrodynamic moment acting on a body of arbitrary shape, advancing at a sufficiently great depth below the free surface of a liquid, using the method of N. E. Kochin [*Sbor. Soch., Izd-vo Akad. Nauk SSSR,* 1949] for determining the hydrodynamic moment acting on a body of arbitrary shape moving at some depth below the free surface of a liquid. The moment is determined from the velocity potential, which was expressed by Kochin as a particular function $H(k, \alpha)$. As a result, a melting moment is obtained, a trimming moment, and a yawing moment through the function $H(k, \alpha)$, which may be calculated, if, on the surface of the body, the distribution of the velocities, or density of the distributed sources, are known. This density can be found from the boundary condition of the flow round the body. The results obtained are applied to the case of a surface ship of narrow beam, without demonstrating the applicability of Kochin's method in the particular case. Simplified expressions are then found for the buoyancy and moment of trim, with the help of which curves are plotted for different, relative elongations of the ship (different degrees of fineness? Transl.). The calculated results agree well with the experimental results obtained by the author. The author is of the opinion that the results of this work may be applied in practice to the investigation of the influence of draught and trim of such a narrow ship on its wave-making resistance, for the study of transverse stability under way, etc.

V. S. Vsitsenya

Courtesy Referativnyi Zhurnal, USSR

4028. Amiradzhibi, R. K., The "coefficient of quantity of motion" in the region of influence of a local hydraulic resistance (in Russian), *Trudi In-ta Energ. Akad. Nauk GruzSSR* **11,** 137-140, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8692.

Consideration of the irregularity of the velocity distribution across the live cross section shows that the local loss by abrupt expansion is approximately equal to half the value obtained by the Borda formula. The author has made measurements of α_0 for a pipe cross section with an area of $\omega(d = 100$ mm), behind a diaphragm (orifice plate) and with an orifice area f, enabling the

curve of change of α_0 along the pipe length to be plotted. The experiments have shown that immediately behind the orifice plate the value of α_0 for $f/\omega = 0.1$, attains 24.5; and for $f/\omega = 0.2$, $\alpha_0 = 12$. At a distance of 5–6d from the plate, α_0 decreases to the original value. The experiments confirm the author's analytical formula $\alpha_0 = \omega/f\varepsilon^2$ (ε = coefficient of compression).

A. M. Latyishenkov

Courtesy Referativnyi Zhurnal, USSR

4029. Liu, H.-K., and Hwang, S.-Y., Discharge formula for straight alluvial channels, *Proc. Amer. Soc. Civ. Engrs.* **85,** HY 11 (*J. Hydr. Div.*), 65–97, Nov. 1959.

The proposed discharge formula contains a discharge coefficient and exponents for hydraulic radius and slope. Both the coefficient and the velocities are given as functions of bed forms and bed material. Velocities computed by the formula check closely with those obtained in the laboratory.

From authors' summary

4030. Nazarov, N. T., The selection of an efficient form of section for a water intake (in Russian), *Trudi Kuibyshevsk. Inzh.-Stroit. In-ta* no. 3, 119–136, 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8648.

An investigation of the flow of a perfect, imponderable and incompressible liquid bounded by two parallel walls, one of which (the upper wall) terminates in a particular, curvilinear obstruction from under which the liquid flows into a constant-pressure region. If the obstruction is assumed to be a curve consisting of segments along each of which the velocity is constant, either in direction or in magnitude, the solution of the problem of defining a flow of this kind can be obtained in a closed (finite) form. In this paper, two such flows are examined, in one of which the above-mentioned obstruction is assumed to be a straight-line segment or "screen," and in the other case, an arc along which the velocity is assumed to be constant, and a straight-line segment. The solution for the first case has been stated by N. E. Zhukovsky, R. Mises, and others; the solution of the second case is given in the present paper, using the method of conformal transformation of the region of the hodograph and the region of variation of the complex flow potential, on the upper auxiliary semiplane. Applying the results of these solutions and experimental data, author concludes that the most effective form of cross-sectional outline for a water intake in hydraulic engineering structures consists of a straight line and an associated curve conforming to the free surface of one of these types of flow.

G. N. Pyikhteev

Courtesy Referativnyi Zhurnal, USSR

4031. Rakhmanov, A. N., Characteristics of the action of the bottom hydraulic jump on the channel bottom (in Russian), *Gidrotekh. Stroit.* **28,** 2, 43–46, Feb. 1959.

For the design of river bed protections at the foot of spillways it is useful to know the size of noncohesive materials that are in the state of limit or critical equilibrium under the action of the bottom current. The corresponding soil grain diameter is called critical. The author made numerous experiments in a glass rectangular flume 0.26 cm wide to obtain a relationship between the critical size of soil grains and the characteristics of the bottom jump formed downstream of the spillway in a horizontal channel. Graphical experimental relationships were obtained between the critical diameters d and distances s from the beginning of the jump. On a set of graphs are plotted values d/h_1 versus s/h_1, where h_1, using Bakhmeteff's terminology, is the depth at the vena-contracta. The graphs are given for different values of the jump characteristics, h_2/h_k, and for the different degree of submergence of the jump, where h_2 is the conjugate and h_k the critical depth. It is possible to obtain from these graphs the critical diameters at any location on the length of the stream from the point where h_1 is located. The author discusses in detail the character of change of critical diameters on the length of the jump and below it for different flow characteristics. The obtained graphical relations are presented on a sufficiently large scale which makes possible to use them for practical computations.

In reviewer's opinion, these results are a valuable contribution to the knowledge of erosion processes at the foot of spillways and may be useful for designers, particularly when many conditions of gate openings and tailwater levels must be investigated. The optimum length of the apron for these conditions and the length of the stream bed protection downstream of it may be designed for dams built in sandy river beds.

B. S. Browzin, USA

4032. Entrances to conduits of rectangular cross section; investigation of entrances flared in three directions and in one direction, Wwys. Exp. Sta. Tech. Mem. 2-428, 51 pp., June 1959.

Tests of conduit entrances flared in three directions and in one direction were conducted to develop entrance shapes which would not be damaged by cavitation and yet would be as small as possible in cross section. Pressure measurements were made on a transparent conduit, 0.283 ft wide by 0.500 ft high by 8.64 ft long, connected to a steel pressure head-bay tank.

Test results indicate that pressure conditions probably acceptable for most installations can be obtained by the use of elliptical entrance curves with the minor axis equal to one-third the major axis. For entrances flared in three directions, the major axes for the entrance curves should be equal to the dimensions of the conduit proper in the directions concerned. For an entrance in which only the top is flared, the major axis of the entrance curve should be equal to at least 1.5 times the depth of the conduit proper.

At installations where high heads and little back pressure result in hydraulic conditions highly susceptible to cavitation, an entrance formed by a compound elliptical curve is desirable.

From summary

4033. Melkonian, G. I., The problem of the circulation around an arc of a two-dimensional flow and its practical applications (in Armenian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-Mat. Nauk* **10,** 2, 89–104, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8649.

The problem is examined of a laminar, cavitational flow around a curvilinear arc, of a perfect, incompressible fluid, bounded by plane-parallel walls. An approximate solution is given for the case of a symmetrical flow around a circular arc, as outlined by D. A. Efross [*Dokladi Akad. Nauk SSSR (N.S.)* **51,** no. 4, 1956]. Equations are set up for the approximate determination of the first three coefficients of resolution of the fundamental function characterizing the flow; the relationships for determining the parameters of the problem are indicated. The flow around such an arc according to Kirchhoff's system is also investigated.

Ya. I. Sekerzh-Zen'kovich

Courtesy Referativnyi Zhurnal, USSR

Incompressible Flow

(See also Revs. 3848, 4033, 4048, 4081, 4083, 4085, 4091, 4097, 4125, 4149, 4157, 4219, 4235, 4271, 4272, 4278, 4352, 4353, 4365)

4034. Irmay, S., On some properties of isoclines in two-dimensional flow (in French), *Houille Blanche* **14,** 6, 749–761, Nov. 1959.

Paper is presented in both French and English. Properties of isoclines, i.e. lines of constant inclination of velocity vector, are discussed. No specific problem is solved. Relationships between isoclines and other properties are given for various flow conditions. If the isoclines or one of the other properties are known, either from an analytical solution or experimental determination, the remaining properties can be obtained.

P. G. Bhuta, USA

4035. Tritton, D. J., Experiments on the flow past a circular cylinder at low Reynolds numbers, *J. Fluid Mech.* **6,** 4, 547–567, Nov. 1959.

Some very interesting experiments are reported on the drag of circular cylinders computed from the bending of quartz fibers in an air stream. The measurements agreed reasonably well with previous experimental and theoretical investigations. However, studies of the frequency of eddies shed by the cylinder indicated a small but definite transition at a Reynolds number of about 90. Flow visualization experiments indicate that the change is from a vortex street originating in the wake to one originating in the immediate vicinity of the cylinder.

W. Squire, USA

4036. Sparrow, E. M., and Loeffler, A. L., Jr., Longitudinal laminar flow between cylinders arranged in regular array, *AIChE J.* **5,** 3, 325–330, Sept. 1959.

The title problem, whose approximate solution is discussed in this paper, is simplified greatly by the observation that the flow is governed exactly by a Poisson's equation. The remaining difficulty, that of finding a method of satisfying the boundary conditions, is resolved approximately. The pressure drop calculated by this method is compared with available experimental pressure drop. The agreement of these pressure drops is within the experimental error, thus justifying the approximate solutions.

The results show the strong effects of geometry upon the pressure drop, from which it may be inferred that more definite physical models will be needed to treat either consolidated or unconsolidated porous beds.

Reviewer believes that this paper will be useful to those designers who are interested in flow processes having unusual geometric configurations. E. E. Covert, USA

4037. Litvinkov, S. S., On a boundary value problem for the linearized equations of viscous flow, *Soviet Phys.-Doklady* **4,** 2, 280–283, Oct. 1959. (Translation of *Doklad Akad. Nauk SSSR (N.S.)* **125,** 5, 998–1001, Mar./Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

4038. Vorovich, I. I., and Yudovich, V. I., Steady flow of a viscous fluid, *Soviet Phys.-Doklady* **4,** 1, 50–53, Aug. 1959. (Translation of *Doklad Akad. Nauk SSSR (N.S.)* **124,** 3, 542–545, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

4039. Ladyzhenskaya, O. A., Stationary motion of viscous incompressible fluids in pipes, *Soviet Phys.-Doklady* **4,** 1, 68–70, Aug. 1959. (Translation of *Doklad Akad. Nauk SSSR (N.S.)* **124,** 3, 551–553, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

4040. Schultz-Grunow, F., Repulsive effect of walls in frictionless shear flow (in German), *Ing.-Arch.* **28,** 307–312, Mar. 1959.

Obstacles moving with basically rectilinear shear flow near flat wall are considered, in which obstacle moves with flow. In plane case, a cross section of a right circular cylinder is considered. Remark that basic flow is augmented by a potential flow is followed by calculation of stream function by recursive process: Flow is reflected at wall, and stream function is built up by adding first a term to cancel normal component on original cylinder, and then a term to do same on reflected cylinder. Process converges. Pressure on cylinder and wall are calculated to show that wall repels cylinder. Next considered is spatial case in which cross section of obstacle perpendicular to flow is finite. It is argued that results of plane case are applicable in first approximation when cross section stretches out along flow.

Report of experimental verification of results by optical methods using polystyrene solution follows.

B. Bernstein, USA

4041. Milne-Thomson, L. M., Tangent flows, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 213–217,

A method is developed for analysis of free-streamline flows of frictionless liquids under the influence of gravity. An equation for a modified flow, called the tangent flow, is written in a form like that for weightless flow and the resulting free-stream configuration is shown to approach that for zero gravity as the gravitational field becomes weak. However, boundary conditions for the tangent flow may not coincide with those for the given flow, as an example illustrates. Further development of the method is needed before it can be applied to practical problems.

D. W. Appel, USA

4042. Roy, Durga, Resistance on a circular cylinder due to any number of vortices lying in two rows (in English), *ZAMP* **10,** 5, 502–508, Sept. 1959.

Author calculates the resistance experienced by a circular cylinder in an uniform flow with a wake of vortices. The present paper differs from what has been done previously in that it yields an exact expression for the instantaneous resistance, instead of merely a time-average. This is achieved, however, only by limiting the attention to the case of a circular cylinder. Paper is of mathematical interest. D. Gh. Ionescu, Roumania

4043. Tsakonas, S., Analytical expressions for thrust deduction and wake fraction for potential flows, *J. Ship Res.* **2,** 1, 50–59, June 1958.

The hull is represented by discrete sources and sinks of known strength. In extension of well-known literature the thrust distribution over the propeller disk area is assumed to be circumferentially variable. Correspondingly the propeller inflow is represented by a uniform distribution of sinks and by a superimposed sink distribution of cosine variation. As a result the effect of a nonuniform thrust distribution on the potential part of the thrust deduction fraction is obtained. H. W. Lerbs, Germany

4044. Martensen, E., Computation of pressure distribution in airfoils with two-dimensional potential flow with a Fredholm integral equation (in German), *Arch. Rational Mech. Anal.* **3,** 3, 235–270, Mar. 1959.

The paper presents theorems on which the theory of an airfoil in a cascade is based.

The computation of pressure distribution leads to the problem in which the Fredholm integral equation of second kind must be solved. The solution of this equation is deduced in a numerical way: the value of the integral in the deduced equation is computed with the aid of a quadrature formula for equidistant values of arguments. In this way the integral equation is transformed to the system of linear algebraic equations.

There are also presented the numerical results for profile $x(\varphi) = a\cos\varphi$; $y = t\{\arccos[\cosh 2\pi x(\varphi)/t]/\cosh 2\pi a/t\}\cdot(2\pi)^{-1}$ with pitch-chord ratio $t/2a = 1$; 0.4; 0.2.

Reviewer is of the opinion that many theorems presented in the paper are well-known and that many of them were deduced by A. W. Goldstein and M. Jerison [see NACA TR no. 869]. The assumptions of present author's theorems are more general than those of Goldstein and Jerison; this novelty which the paper brings, e. g. the condition for behavior of the velocity at an infinitely distant point from the cascade, is interesting rather from the mathematical than from the technical point of view.

M. Ruzicka, Czechoslovakia

4045. Arkhipov, V. N., The formation of streaming fluctuations behind a solid obstacle, *Soviet Phys.-Doklady* **3,** 6, 1117–1120, June 1959. (Translation of *Doklad Akad. Nauk SSSR (N.S.)* **123,** 4, 620–622, Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author employs the familiar hydrodynamic stability equation to investigate the flow behind a cylinder of arbitrary shape. For this he uses the velocity distribution in a wake as obtained by Tollmien. Galerkin's method is employed to solve the disturbance differential equation. Computations showed that nonsymmetrical perturbations are more critical than symmetrical ones; the customary $\alpha - Re$ curve is obtained for the nonsymmetrical case. Experimental data of others for the case of circular cylinders are compared with author's theoretical results. It is concluded that the growth of disturbances in a wake, as predicted by linear hydrodynamic stability theory, is in "fairly good accordance with experimental data relative to the formation of vortex sheets."

R. B. Banks, USA

4046. Bazilevich, A. I., and Levitskiy, B. F., The energy transformation in the abrupt expansion of a flow (in Russian), *Dokladi L'vovsk. Politekhn. In-ta* **2**, 1, 57–60, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8724.

Experimental results confirm those of other authors to the effect that on the sudden expansion of the flow in pressure pipelines the fading length of the excess kinetic energy represents about 60 to 80 pipe diameters. The geometrical proportions of the experimental pipelines, as well as the data on the character of the fading curve of the excess energy along the flow length, are not given in the paper.

M. E. Faktorovich

Courtesy Referativnyi Zhurnal, USSR

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 3779, 3833, 4034, 4081, 4082, 4092, 4099, 4100, 4110, 4115, 4120, 4121, 4122, 4126, 4134, 4135, 4137, 4141, 4166, 4170, 4178, 4179, 4184, 4186, 4187, 4226, 4227, 4228, 4229, 4231, 4251, 4265, 4273, 4274, 4275, 4276, 4277, 4297, 4379)

4047. Coburn, N., A note on "The method of characteristics for a perfect compressible fluid in general relativity and non-steady Newtonian mechanics," *J. Math. Mech.* **8**, 5, 787–792, Sept. 1959.

In a previous paper [Coburn, N., *J. Math. Mech.* **7**, 449–482, 1958; AMR **12** (1959), Rev. 4007] author derives characteristic equations, for flow described in title, under the assumption that the speed of sound is negligible compared with the speed of light. This restriction is removed in the present note and the definition of order of magnitude of physical quantities is clarified.

M. Holt, USA

4048. Serrin, J., On the uniqueness of compressible fluid motions (in English), *Arch. Rational Mech. Anal.* **3**, 3, 271–288, Mar. 1959.

Author proves uniqueness of fluid motion in bounded region $V(t)$, given initial velocity, temperature and density distribution. Advance on previous treatments is that fluid is not piezotropic but has general equations of state of form $p = p(\rho, T)$ and $E = E(\rho, T)$ where $(\partial E/\partial T)_\rho > 0$. The nature of boundary conditions assigned depends on whether U, the relative outward normal fluid speed at boundary, is positive, negative or zero, but in all cases the conditions assumed are physically plausible, except perhaps for use of Newtonian law of cooling.

The proof uses the classical energy method together with global transport equation for functions defined over V. Main results are given in five theorems. Theorem 2 treats special case of an inviscid fluid (without shocks) for which $p = p(\rho, S)$, $(\partial p/\partial \rho)_S = c^2 > 0$, and is a generalization of the familiar case of one-dimensional unsteady motion of a gas.

H. C. Levey, Australia

4049. Power, G., and Smith, P., Approximate subsonic gas flows under assigned boundary conditions, *Appl. Scient. Res.* (*A*) **8**, 5, 349–356, 1959.

Using a straight-line approximation to the equation of state, compressible flow problems under fully assigned boundary conditions are discussed. It is shown that Schwarz's results on minimal surfaces can be immediately applied for two-dimensional flow, and several special cases are treated. As an example, the flow around a parabolic cylinder over which the fluid velocity is constant and normal to the cylinder is solved. Extensions of these results provide certain particular types of three-dimensional flow.

M. Kawaguti, Japan

4050. Power, G., and Smith, P., Application of a reciprocal property to subsonic flow, *Appl. Scient. Res.* (*A*) **8**, 5, 386–392, 1959.

A reciprocal property for the two-dimensional, irrotational flow of a compressible fluid is derived. From this certain flows can be obtained which possess the property of having simply-related velocity potentials and stream functions. To each flow pattern there corresponds a certain pressure density law. Using this property, an approximate method for subsonic flow is deduced which is very close to the one obtained earlier by the authors [AMR **12** (1959), Rev. 4566].

M. Kawaguti, Japan

4051. Randall, D. G., Transonic flow over two-dimensional round-nosed aerofoils, Aero. Res. Counc. Lond. Curr. Pap. 456, 28 pp., 1959.

The approximate solution of the transonic flow equation developed by Spreiter and Alksne [AMR **11** (1958), Rev. 537] is extended to round-nosed airfoils with profiles for which the expansion about the leading edge, $X = 0$, contains terms in either $X^{3/2}$ or X (but not both). Calculated pressure distributions for Mach number 1 are compared with experimental values for an NPL 491 profile.

G. E. Nitzberg, USA

4052. Vaglio-Laurin, R., Transonic rotational flow over a convex corner, AFOSR TN 59-355 (Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech. Rep. 431; ASTIA AD 213 681), 56 pp., Aug. 1959.

Author gives, based on a perturbation scheme, a "boundary layer" (or asymptotic) approach joining the subsonic and supersonic regions of the title problem. The pertaining equation is then solved by assuming a series solution. The leading coefficient is analogous to that of the corner problem in supersonic flow and subsequent coefficients are obtainable from a set of linear equations. Paper concludes with a brief discussion of the application of the result.

L. N. Tao, USA

4053. Hancock, G. J., Notes on thin wing theory at low supersonic speeds, Part I: The design of lifting surfaces, *Aero. Quart.* **10**, 3, 247–265, Aug. 1959.

A numerical method is given for calculating incidence and camber for a specified loading on a given thin wing at zero yaw. Using linearized theory, an integral relation between incidence and velocity potential is derived for wings with subsonic leading edges.

For simple planforms (delta wings and untapered sweptback wings) a mathematical expression for incidence is derived for the case of uniform loading. For general planforms, a simple approximate numerical method is given, based on finite difference methods applied to a Mach line mesh across the wing. Details are given of refinements to be used near the leading edge.

Good agreement with theoretical results is obtained, except near the leading and trailing edges. Method is of general application, and numerical techniques can be carried out on a desk computor.

A. W. Babister, Scotland

4054. Hancock, G. J., Notes on thin wing theory at low supersonic speeds, Part II: A unified numerical method for the calculation of the loading on wings with subsonic leading edges, *Aero. Quart.* **10,** 4, 319–325, Nov. 1959.

Using the theory of part I (see preceding review), a numerical method is given for calculating the velocity potential (and hence the loading) on a given thin wing at zero yaw when the incidence distribution is known. This is the inverse problem to that in part I; solution is obtained by matrix inversion.

Method is applied to a delta wing with subsonic leading edges. Results agree well with linearized theory. Numerical method described is completely general for wings with subsonic leading edges, for any camber and trailing edge conditions.

A. W. Babister, Scotland

4055. Khaskind, M. D., and Khomenko, V. S., Flow past a profile in a bounded supersonic stream, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22,** 6, 1162–1168, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Two-dimensional, steady, supersonic flow around a body between rectilinear, parallel boundaries is considered. Legendre transformation is applied to general equations of isentropic, irrotational flow and symmetric linear equations are obtained. Resulting expression for pressure distribution reduces to linearized theory when appropriate simplifications are introduced.

Method appears to have some utility when conditions of the analysis are met. However, there will be many cases where it is not appreciably more difficult to use exact methods, thereby avoiding limitations of the approximate analysis. The example chosen to demonstrate the difference in results of linearized and the authors' theories is such a case. Reviewer suspects a mistake in calculations presented in the example.

J. L. Potter, USA

4056. Bird, G. A., A simple numerical solution of the flow around a blunt body in a supersonic stream—with application to real gases, Austral. Defense Scient. Service, Weapons Research Establishment TN HSA 52, 24 pp., Sept. 1959.

It is shown that a satisfactory numerical solution of the steady inviscid flow behind an axisymmetric or plane detached shock wave can be obtained by a stream tube method which makes use of only elementary forms of the equations of motion. This enables the perfect gas assumption to be discarded when it ceases to be applicable in hypersonic flow, and the calculations may be based on the real gas properties. Results are given of the hand computation of the flow behind a paraboloidal shock wave in the flow of air at a Mach number of 20 for the three assumptions of perfect gas, real gas in thermodynamic equilibrium everywhere and real gas with the composition frozen during expansion processes. Results are also given for the flow behind the shock wave actually produced by a flat-nosed body of revolution at a Mach number of 2.4.

From author's summary

4057. Freeman, N. C., A note on the explosion solution of Sedov with application to the Newtonian theory of unsteady hypersonic flow, *J. Aero/Space Sci.* **27,** 1, 77–78 (Readers' Forum), Jan. 1960.

Author uses Newtonian hypersonic flow theory to derive simply the formulas obtained from Sedov's self-similar analytic flow solution in the limit as γ tends to one. He shows that consistency is obtained provided one shuns the approximation that conditions are isothermal along a streamline, which is not true except near the shock.

Reviewer feels that author has fallen into this very trap in stating his equations [3] and [5] for density and temperature in the flow. In each of these the factor $(r_0/r_s)^2$ should be replaced by $(r_0/r_s)^\epsilon$, in reviewer's opinion. This alteration is important for the small fraction of the material which is not just behind the shock.

It also seemed to the reviewer that a factor 2 had been omitted from equation [12] and therefore, perhaps, from equations [1] and [2].

A. H. Armstrong, England

4058. Creager, M. O., An approximate method for calculating surface pressures on curved profile blunt plates in hypersonic flow, NASA TN D-71, 27 pp., Sept. 1959.

A hybrid Newtonian-blast wave theory in conjunction with Hammitt's weak interaction theory is used to yield results in good agreement with experiment.

H. Yoshihara, USA

4059. Freeman, N. C., The "Newtonian" theory of hypersonic flow for any three-dimensional body, Aero. Res. Counc. Lond., Curr. Pap. 439, 21 pp., 1959.

Paper extends the "Newtonian plus centrifugal" theory which was developed earlier by the author [*J. Fluid Mech.* **1,** 4, 366–387, Oct. 1956; AMR **10** (1957), Rev. 3704] for calculating the inviscid flow over plane and axially symmetric bodies. Application is restricted by assumptions that the free-stream Mach number is infinite and the specific heat ratio is near one. Expressions are found for the surface pressure and the shock shape in terms of curvilinear coordinates on the surface and distance along the streamlines. In general, this latter coordinate cannot be readily determined and further consideration is limited to slightly yawed bodies of revolution, for which an expression is found for the pressure field. This is applied to a slightly yawed cone and results are given for the surface pressure and shock shape.

G. A. Bird, Australia

4060. Chubb, D. L., Solution to the flow about a two-dimensional flat plate at infinite Mach number, *J. Aero/Space Sci.* **27,** 1, p. 68 (Readers' Forum), Jan. 1960.

To obtain a solution to the flow about a flat plate aligned perpendicular to the free stream at infinite Mach number, a mathematical technique known as the "method of integral relations" was used. This method was first proposed by Dorodnitsyn; a thorough explanation of Dorodnitsyn's method is given by Hayes and Probstein. In the solution, it has been assumed that the flow is homoenergetic and that the gas is calorically perfect.

From author's summary

4061. Treanor, C. E., and Williams, Marcia J., A graphical solution of shock equations, AFOSR TN 59–1088 (Cornell Aero. Lab. Rep. AD-1118-A-4), 32 pp., Nov. 1959.

A rapid graphical method for calculating the conditions behind a normal shock is described. The method applies to any gas for which the enthalpy is known as a function of pressure and density. The accuracy is limited only by that of the available graph of the gas properties. The necessary working graphs for air, O_2 and N_2 (complete thermodynamic equilibrium) and for NO (without chemical reaction) are included, along with a template for use in attaining the solution.

From authors' summary

4062. Smith, W. R., Mutual reflection of two shock waves of arbitrary strengths, *Physics of Fluids* **2,** 5, 533–541, Sept./Oct. 1959.

Author investigates interaction of two weak shock waves to determine conditions for appearance of Mach intersection. This is best determined from slip streams (vortex sheets) appearing in shadow or schlieren photographs; interferograms are considered by author to be useless for this purpose. Regular reflection data agreed with weak shock-flow solution, Mach reflection being found for deflections larger than extreme angle. Experiments shed no new light on failure of three-shock theory to account for Mach reflection configuration.

E. W. E. Rogers, England

4063. Glass, I. I., and Heuckroth, L. E., Head-on collision of spherical shock waves, *Physics of Fluids* **2,** 5, 542–546, Sept./Oct. 1959.

Colliding shock waves and the associated spherical flow are studied using blasts from exploding glass spheres containing air or helium up to 500 psi. Interactions are successfully investigated using shadowgrams, multispark (Cranz-Schardin) schlieren photographs and wave-speed records. Results are compared with theory, but complications arise because of finite duration of breaking process of glass sphere and ensuing turbulence at contact front.

E. W. E. Rogers, England

4064. Cloupeau, M., Experimental studies of shock waves produced by discharged condensors in rarefied gases (in French), *Publ. Scient. Tech. Min. Air, France* no. 352, 62 pp., 1959.

Phenomena associated with spark discharges in low pressure gases are studied. Spectral energy as a function of time is measured. The effect of shock waves in the gas is recognized and shown to be important. Careful attention is given to line and continuous spectra. Previous work is discussed. The present experimental technique, obtained results, and their interpretation are given in detail. Xenon is the gas employed.

R. A. Gross, USA

4065. Randall, D. G., Methods for estimating distributions and intensities of sonic bangs, Aero. Res. Counc. Lond. Rep. Mem. 3113, 32 pp., 1959.

Methods recently developed for estimating distributions and intensities of sonic bangs are described. They are applied to several interesting flight maneuvers and the results discussed in detail. The effect of refraction on sonic-bang distributions and intensities (caused by the temperature gradient existing in the actual atmosphere) is also considered.

F. S. Sherman, USA

4066. Dyer, I., Distribution of sound sources in a jet stream, *J. Acoust. Soc. Amer.* **31,** 7, 1016–1022, July 1959.

It is shown that the axial distribution of sound sources in a turbulent jet stream can be found simply in terms of (1) the spectrum of the total radiated power and (2) the frequency of the sources as a function of location along the jet axis. With the use of existing data on the sound power spectrum and recently reported but preliminary data on the frequency dependence of the most probable source location, an approximate axial distribution is derived. The derived distribution is in agreement with calculations by Sanders based on turbulence measurements, and with calculations by Ribner based on Lighthill's theory.

From author's summary by R. E. Goode, USA

4067. Reeves, B. L., and Van Camp, W. M., Aerodynamic heating of simple geometries in the slip- and intermediate-flow regimes, *J. Aero/Space Sci.* **26,** 12, 838–839 (Readers' Forum), Dec. 1959.

This brief paper presents empirical relationships for determining the aerodynamic heating rates and temperature recovery factors for the flow of a moderately rarefied gas over flat plates, cones, spheres, and transverse cylinders.

From authors' summary

4068. Erickson, W. D., and Creekmore, Helen S., A study of equilibrium real-gas effects in hypersonic air nozzles, including charts of thermodynamic properties for equilibrium air, NASA TN D-231, 179 pp., Apr. 1960.

Flow parameters given in chart form and calculated for air as a real gas in chemical equilibrium for a series of stagnation temperatures between 2,790 R and 4,950 R and pressures up to 1,000 atm are presented. From these charts it is possible to calibrate a hypersonic nozzle in the conventional way. A method is shown for calculating an inviscid nozzle contour including real-gas effects. Charts of thermodynamic properties for air from which these calculations were made and from which additional calculations may be made are included. Also presented is the limiting Mach number for condensation as a function of stagnation temperature and pressure.

From authors' summary

4069. Visich, M., Jr., and Libby, P. A., Experimental investigation of mixing of Mach number 3.95 stream in presence of wall, NASA TN D-247, 47 pp., Feb. 1960.

An experimental investigation of the turbulent mixing of a supersonic stream with a subsonic stream bounded by a wall is described. The Mach number of the main stream was 3.95 while the mass flow of the secondary stream was varied from zero to a value assuring subsonic flow at the origin of mixing. The total-head profiles are interpreted in terms of velocity profiles which are correlated in terms of an extension to the compressible case of the law of the wall and the law of the wake.

From authors' summary

4070. Pounder, E., and Copper, J., Remarks on a study of short, flexible nozzles, *J. Aero/Space Sci.* **27,** 1, 73–74 (Readers' Forum), Jan. 1960.

To determine minimum useful flexible-plate nozzle lengths, the established flow has been studied as the nozzle design parameters approach theoretical limits. The results show that for the CWT Mach number range, the partial-cancellation parameter θ_{1P}/θ_i can reach at least 0.7; and the expansion ratio θ_i/ν_i can approach 1.0 without loss of flow quality. These limits result in nozzle lengths only about 10% longer than those for comparable Foelsch-type nozzles.

From authors' summary

4071. Slezkin, N. A., On the development of the flow of a viscous heat-conducting gas in a pipe, *Appl. Math. Mekh.* (*Prikl. Mat. Mekh.*) **23,** 2, 473–489, 1959, (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Paper considers development of compressible Poiseuille flow in entrance region of circular pipe. Method combines boundary-layer and Oseen approximations, thus reducing equations of motion to simultaneous linear partial form, which are solved by operational calculus.

Method is neat, and yields useful results, but is not new. Similar approach was used by Tulin [AMR **4** (1951), Rev. 1312] in studying unsteady boundary layers.

N. Curle, England

4072. Sretenskii, L. N., On the theory of gaseous jets, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 2, 436–472, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Paper discusses some problems of two-dimensional compressible inviscid jet flow, using methods of Chaplygin: (1) Finite jet impinging on symmetrically placed converging straight walls, and issuing through orifice formed by them. (2) Jet impinging on normally placed plate, with finite stagnation region in front. Region does not extend to edge of plate, and bounding streamline does not impinge on plate at zero angle, when jet has finite width. (3) Generalization of incompressible flow solutions, due to Zhukovskii, for jets issuing from vessels.

Paper is valuable contribution to literature on subject.

N. Curle, England

4073. Smith, M. G., The behaviour of an axially symmetric sonic jet near to the sonic plane, *Quart. J. Mech. Appl. Math.* **12,** 3, 287–297, Aug. 1959.

Author makes an analytical study of the sonic region of an axially symmetric underexpanded jet. The dependent variables are expanded around the sonic region. After investigating the singularity at the sonic plane, the lowest terms of the expansion are obtained. The solution is compared to the corresponding two-dimensional result. It is pointed out that this solution can be used as the starting point for the characteristic net in the solution of the whole jet flow.

T. C. Adamson, Jr., USA

4074. Le Grives, E., and Larue, P., Optimum proportions of rocket propulsion nozzles (in French), ONERA Pub. 69, 9–14, Mar./Apr. 1959.

Analytic method is given of optimizing simple rocket performance (burnout velocity) for vertical trajectory neglecting drag in relation to nozzle area ratio and weight. The nozzle divergence is taken as linear, with linear wall thickness taper. Graphs of parameters are given, together with numerical examples. A comparison is made between results assuming equilibrium and frozen composition. D. G. Shepherd, USA

4075. Soffker, E., Contribution to the inlet problem for jet engines at supersonic flow (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 108–117.

Compression shocks on air intakes of jet engines at supersonic speed have a considerable reducing effect on the thrust due to the increase in entropy. Therefore, distinct shock systems are chosen to reduce these losses. Real supersonic intakes, however, present difficulties in the case of the other extreme operational condition, i. e. during take-off. The present paper deals with a new diffuser which is designed to take into account the conditions at high speed as well as those during take-off without the necessity for mechanical adjustment. Maximum values of pressure recovery of 94% including the losses in the subsonic diffuser are obtained at a Mach number of 1.94. Reducing the mass flow ratio to 60% of the maximum value has practically no effect on the pressure recovery. Experiments at take-off conditions have also shown promising results. Using side flaps, pressure recovery may be expected to be larger than 97%, even at maximum mass flow.

From author's summary

4076. Henderson, L. F., A two-dimensional theory of the oblique shock intake based on the hodograph method, Aero. Res. Lab., Melbourne, Austral. Rep. ME 90, 54 pp., Mar. 1959.

A two-dimensional theory of the single oblique shock intake is constructed with the aid of the hodograph transformation. This gives more information than the corresponding one-dimensional theory and provides a sounder basis for design and performance studies. From author's summary

4077. Freeman, N. C., Non-equilibrium theory of an ideal-dissociating gas through a conical nozzle, Aero. Res. Counc. Lond. Curr. Pap. 438, 10 pp., 1959.

One-dimensional flow of Lighthill's ideal-dissociating gas through a conical nozzle is investigated using the simple rate equation of Freeman. Effects of the rate parameter Λ are investigated by solving numerically two simultaneous nonlinear ordinary first-order differential equations for the amount of dissociation α and density ρ. The dissociation in the nozzle takes place at first near the equilibrium value and then quickly approaches to the constant value of α_∞. Density differs very little for wide range of Λ. An approximate solution is presented by substituting the equilibrium value ρ_e into density.

Results are similar with those obtained by K. N. C. Bray [Aero. Res. Counc. TR 19,983, Mar. 1958] and S. P. Heims [NACA TN 4144, Jan. 1958; AMR **11** (1958), Rev. 3144].

S. Uchida, Japan

4078. Vincenti, W. G., Non-equilibrium flow over a wavy wall, *J. Fluid Mech.* **6,** 4, 481–496, Nov. 1959.

Object of this paper is to gain some understanding of non-equilibrium flows by studying a relatively simple case that can be solved analytically. To this end author considers steady, two-dimensional, small disturbance flow over a wavy wall of an inviscid fluid which is not in chemical or vibrational equilibrium. The usual conservation equations as well as those describing the nonequilibrium thermochemical properties of the gas are linearized and combined to yield a third-order linear partial differential equation for the perturbation velocity potential. This equation is analogous to the Prandtl-Glauert equation. For example, in the limit of zero relaxation time the equation reduces to the P–G equation for equilibrium flow; for infinite relaxation time (i.e., frozen flow) the equation reduces to the P–G equation with Mach number based on frozen speed of sound. The solution to this equation, for the flow over an infinite sinusoidal wall, is determined. It is seen that the inclusion of nonequilibrium effects eliminates the characteristic feature of the classical Ackeret solution, namely, the singular behavior in the transonic region. Moreover, nonequilibrium effects give rise to finite pressure drag at subsonic speeds. A. Ritter, USA

4079. Prussov, V. M., The problem of integrating the equations of unidimensional, unsteady motion of a gas (in Russian), *Ucb. Zap. Petrozavodskogo In-ta* **4,** 4, 59–68, 1955 (1957); *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8460.

The equations of the unidimensional (plane-wave), adiabatic and isentropic motions of a gas are examined; the author suggests a method of approximation for their integration, founded on the known fact of the existence of a mathematical analogy between the equations in question and the equations of the two-dimensional, isentropic, steady motion of a gas. This analogy enables various approximation methods of integrating the latter equations, developed by S. A. Chaplygin, S. A. Khristianovich, and L. I. Sedov, to be transformed into the equations of unsteady motion, which is the essential theme of the present work. S. S. Grigoryan

Courtesy Referativnyi Zhurnal, USSR

Boundary Layer

(See also Revs. 4040, 4045, 4056, 4071, 4109, 4183, 4218, 4220, 4222, 4224, 4225, 4235, 4240, 4241, 4277, 4333)

4080. Schlichting, H., Some developments in boundary layer research in the past thirty years, *J. Roy. Aero. Soc.* **64,** 590, 64–79, Feb. 1960.

4081. Bloom, M. H., and Rubin, S., High-speed viscous corner flow, WADC 59-312 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 530), 25 pp., Aug. 1959.

Authors present an analytical treatment of the region of interference due to the merging of wall boundary layers at an inside corner. A momentum integral method which is restricted to flows symmetric to the bisector of the corner, essentially an extension of Loitsianskii and Bolshakov's work (1936), is used. Values of a dimensionless *interference parameter* are presented for several corner angles as a function of Mach number for laminar, constant density, perfect gas flow with a Prandtl number of unity. With these conditions, increasing either the corner angles or the Mach number results in a decreased corner interference, and the interference becomes negligible at moderate supersonic Mach numbers.

Reviewer believes that it is interesting to note that Eq. [38] is applicable to the isoenergetic boundary layer (adiabatic wall) if $[1 + c]$ is substituted for $\bar{h}_w$. For such cases the corner interference is even less than the calculated constant density case.

R. H. Page, USA

4082. Schaaf, S. A., Hurlbut, F. C., Talbot, L., and Aroesty, J., Viscous interaction experiments at low Reynolds numbers, *ARS J.* **29,** 7, 527–528 (Tech. Notes), July 1959.

Data are presented which seem to indicate some agreement with the expectation that surface pressure near the leading edge of a very sharp flat plate at zero angle of attack is substantially below that existing behind a normal shock. As a consequence of the data reported the existence of slip flow phenomenon is suggested.

M. J. Goglia, USA

4083. Datta, S., A note on the motion of viscous fluid subjected to uniform or periodic body force acting for a finite time, *J. Technol.* **3,** 2, 73–79, Dec. 1958.

The motion of a viscous incompressible fluid between two parallel planes and through a circular pipe is considered, under the assumption that a body force X acts for a finite time T. Analytical results for the fluid velocity $u(y, t)$ are derived by Laplace transformation techniques. These show that if X is constant u increases until $t = T$ and then decreases, and that if X is periodic u has a periodic part for $t < T$ and decreases for $t > T$.

D. W. Dunn, Canada

4084. Ting, L., Boundary layer over a flat plate in the presence of shear flow, WADC 59-334 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 524), 13 pp., Aug. 1959.

Author is mostly concerned with extremely large vorticity—as large or larger than that induced by viscosity in the boundary layer. In this case, the effect of the external shear layer is not a perturbation. Similar solutions exist in the limit of large vorticity. An approximately similar result is found for smaller vorticity, which indicates that the limiting result holds whenever the applied shear exceeds that induced by viscosity.

In such cases, the tempest involving Glauert and Li [*J. Aero. Sci.* **24,** 11, p. 848, Nov. 1957] and others is not relevant. However, the author uses, without comment, Li's result in the limit of small vorticity. In this, it is understood that the effect of the boundary layer is to induce a pressure gradient, but no significant perturbation in the external streamwise velocity.

S. H. Maslen, USA

4085. Ku, Y. K., Boundary layer problems solved by the method of nonlinear mechanics (in English), 9th Congrès Intern. Mecán. Appl., Univ. Bruxelles, 1957; **4,** 132–144.

Author applies a technique of nonlinear mechanics to the solution of three boundary-layer equations, namely the Lighthill-Carrier, the Blasius, and the Schlichting equations. Author's solutions remove the linearization restrictions of perturbation theory, and present a worthwhile contribution to boundary-layer mathematics.

G. V. Bull, Canada

4086. Kosterin, S. I., and Koshmarov, Yu. A., The turbulent boundary layer on a flat plate in a uniform stream of a compressible fluid, *Soviet Phys.–Tech. Phys.* **4,** 7, 819–828, Jan. 1960. (Translation of *Zh. Tekh. Fiz., USSR* **29,** 7, 906–915, July 1959 by Amer. Inst. Phys., New York, N. Y.

An analysis of the compressible turbulent boundary layer is based on the Prandtl mixing-length theory and an expression for the turbulent stress which includes density fluctuations. The analysis is straightforward and the final result is shown in the usual form of a plot of the ratio of compressible to incompressible shear coefficient versus Mach number.

Reviewer notes that: (1) The statement in the opening sentence that all previous investigations have neglected density fluctuations is incorrect. D. Coles in a 1953 survey cites three analyses which consider density fluctuations. (2) The experimental data all appear to be from American sources; unfortunately all data and theoretical curves plotted for comparison are only identified by the investigator's name so that the reviewer could not locate certain theoretical papers (Enin, Zhestkov).

(3) The recent work of Hill indicates that the laminar sublayer is not relatively thin at high Mach numbers as assumed in the analysis.

(4) There is a typographical error in Eq. [3] which, however, is not carried over into Eq. [9].

W. Squire, USA

4087. Fedyaevskii, K. K., and Ginevskii, A. S., Non-stationary turbulent boundary layer on a wing profile and on a figure of rotation, *Soviet Phys.–Tech. Phys.* **4,** 7, 829–836, Jan. 1960. (Translation of *Zh. Tekh. Fiz., USSR* **29,** 7, 916–923, July 1959 by Amer. Inst. Phys., New York, N. Y.)

The senior author's analysis of the steady turbulent boundary layer based on combining Prandtl mixing-length theory with a polynomial shear stress distribution is applied to nonsteady flow. The analysis is essentially unchanged except that the usual parameter $(\rho\delta/\tau_0)\,UU_x$ is replaced by $(\rho\delta/\tau_0)(U_t + UU_x)$.

Calculation of the drag of a circular cylinder shows that nonsteady flow has an appreciable effect on the drag, primarily through the location of the separation point. The drag is increased when the flow is accelerated and decreased when it is decelerated. The results for accelerating flow are stated to agree qualitatively with experiments reported by Luneau.

W. Squire, USA

4088. Philip, J. R., Analysis of turbulent boundary layers with zero pressure gradient (in English), *ZAMP* **10,** 5, 478–501, Sept. 1959.

As elaborate mixing-length analysis of the incompressible turbulent boundary layer on smooth and rough walls is presented based on a mixing length $l = ky^m$. On the basis of the experimental data m is taken to be 7/8 and k a complicated function of position.

It is argued that while the mixing-length concept is not literally correct the use of a single universal function is simpler than the two functions (wall law and wake law) used by investigators such as Coles, Clauser and Townsend. An extension of the analysis to non-zero pressure gradients is promised.

Reviewer found the paper interesting but doubts that the trend away from mixing-length theories will be reversed.

W. Squire, USA

4089. Zysina-Molozhen, L. M., The calculation of heat transfer in a cascade of blades, *Soviet Phys.–Tech. Phys.* **4,** 5, 558–563, Nov. 1959. (Translation of *Zh. Tekh. Fiz.* **29,** 5, 625–632, May 1959 by Amer. Inst. Phys., New York, N. Y.)

By linearizing the flow and using integral relations an approximate expression is derived for the average heat transfer to a cascade of blades. The final expression involves both the boundary-layer characteristics of an individual blade (see following review) and cascade properties such as spacing and angle of attack. The expression gives good agreement with the experimental data of Pope and Wilson [*Proc. Instn. Mech. Engrs.* **168,** p. 36, 1954; AMR **8**(1955), Rev. 3906].

W. Squire, USA

4090. Zysina-Molozhen, L. M., An approximate method for calculating the thermal boundary layer, *Soviet Phys.–Tech. Phys.* **4,** 5, 564–570, Nov. 1959. (Translation of *Zh. Tekh. Fiz.* **29,** 5, 632–640, May 1959 by Amer. Inst. Phys., New York, N. Y.)

A semiempirical analysis of the development of the thermal boundary layer in an incompressible flow is presented. An energy thickness, which is analogous to the momentum thickness in skin-friction calculations, is given by an expression involving an integral of the pressure distribution along the surface. Separate forms are given for laminar, transitional and turbulent flow. Corresponding expressions for the Nusselt number are developed.

The emphasis on the transitional range has characterized a number of investigations by the author [AMR **13**(1960), Rev. 1863] which are therefore of particular value to those interested in problems involving moderate Reynolds numbers.

W. Squire, USA

4091. Bogdonoff, S. M., On the interaction of supersonic turbulent boundary layers and shock waves (in English), 9th Congrès Intern. Mecán. Appl., Univ. Bruxelles, 1957; **4,** 145–154.

Author presents a brief review of experimental results obtained in the Gas Dynamics Laboratory of the James Forrestal Research Center of Princeton University. An experimental framework is discussed which can be used to predict separation pressure ratio,

peak pressure ratio and the pressure ratio for incipient separation for supersonic turbulent boundary layers at Mach numbers up to 4. Many of the interesting aspects of the shock wave-boundary layer interaction problem are described; among these one might note the occurrence of peak pressure ratio after separation and its dependency on the size of the separated region, although the pressure ratio at separation is little affected by the separated region. Another interesting point described is that the wall pressure distributions are smooth through the separation point, the occurrence of zero or reverse velocities apparently having no significant effect on the over-all phenomena.

This paper is one of the early works of the author and, it should be noted, is somewhat supplanted by his later and more complete publications. G. V. Bull, Canada

4092. Clutter, D. W., Charts for determining skin-friction coefficients on smooth and on rough flat plates at Mach numbers up to 5.0 with and without heat transfer, Douglas Aircr. Co. Rep. ES29074, 106 pp., Apr. 1959.

4093. Eichelbrenner, E. A., Laval, P., and Werle, H., Laminar separation on a delta wing at zero angle of attack in incompressible flow (in French), ONERA Pub. 70, 11–14, May/June 1959.

Delta wing considered has 60° apex angle, elliptical transverse sections and central chordwise section bi-convex with $t/c = 0.10$. Potential flow pressure distribution was calculated by slender-body theory, although not really accurate for this case. Using this pressure distribution, flow in laminar boundary layer was calculated by method given in AMR **11** (1958), Revs, 227, 2255. Theoretical position of line of separation is compared with position given by visual experiments in water tunnel, using colored water to show streamlines. Some qualitative agreement is obtained, but calculated separation line is ahead of observed line. Authors refer to earlier work by Werlé [ONERA Techn. Note no. 48] indicating that this visual method gives separation line too far downstream. They also point out that vortices from leading edge have not been considered in the theory and that calculated position of separation is sensitive to small changes. A further paper will give theoretical results based on an iterative calculation of pressure distribution, allowing for effect of the separation on the external flow. W. A. Mair, England

4094. Klebanoff, P. S., and Tidstrom, K. D., Evolution of amplified waves leading to transition in a boundary layer with zero pressure gradient, NASA TN D-195, 67 pp., Sept. 1959.

Report describes experimental study of the boundary-layer transition phenomenon on a flat plate in low-speed flow. Many measurements were made, principally with hot wire. Both natural and artificially excited flows, excited by a vibrating ribbon, were investigated. A great wealth of new information has been supplied not only as to the process before the first occurrence of turbulence but also to its spread and development thereafter. Especially interesting is the fact that the original two-dimensional waves in the boundary layer become strongly three-dimensional by a process of lateral transfer of energy into streamwise streets. Turbulence first occurs almost at a point in the outer region of the high energy streets and gradually spreads in a particular fashion. In the reviewer's opinion the work marks an important advance in knowledge and understanding of the process of transition.

A. M. O. Smith, USA

4095. Gibbings, J. C., On the effect of a narrow band of distributed roughness upon boundary-layer transition, *J. Aero/Space Sci.* **26,** 12, 843–844 (Readers' Forum), Dec. 1959.

4096. Research on experimental investigation of variable circulation around an aspirated cylinder (in English), AFOSR TR 59-105 (Institut de Recherches Scientifiques et Techniques du Centre-ouest, Etude IRST-E1/573; ASTIA AD 162 109), 37 pp., 1959.

Measurements of lift and drag on a circular cylinder on which circulation was controlled by a deflector plate normal to the surface and by suction through the cylinder surface. Maximum lift coefficient reached was 2.4 (40% of theoretical maximum) with suction removal of about 10% of the flow through the cylinder projection at a diameter Reynolds number of about 10^5.

A. M. Kuethe, USA

4097. White, F. M., Jr., Barfield, B. F., and Goglia, M. J., Laminar flow in a uniformly porous channel, *J. Appl. Mech.* **25,** 4, 613–618, Dec. 1958.

The authors investigated symmetric two-dimensional laminar flows of a viscous fluid through a channel with uniform suction (or injection) at the walls. With x measured in the direction of flow mid-way between the walls, and y in the direction normal to the walls, the stream function is assumed to be

$$g(x)\, f(\lambda)$$

in which $\lambda = y/b$, b being the half spacing of the walls. (It turned out that $g(x)$ is a linear function of x.) The equations of motion can then be reduced to the form

$$R(f'f'' - ff''') + f'''' = 0$$

in which R is an adequately defined Reynolds number. This equation is then solved by expansion of f in a series of ascending powers in λ and R, which they proved to be absolutely convergent for all finite values of R, however large. Numerical results are obtained by a computer, and the essential difference between the velocity profile for the case of suction and that for the case of injection is well demonstrated. With f known for a given R, the velocity components, the pressure, and the wall-friction coefficient are known.

It would have been more satisfying to the reader if the solutions presented for infinite Reynolds number had been shown to be the limiting forms of the general solution for finite R. Aside from this omission, the paper is a well-written account of an interesting piece of work.

C.-S. Yih, England

4098. Young, A. D., and Kirby, S., Effects on interaction between boundary layers and external stream and of incidence on boundary-layer drag at supersonic speeds, Aero. Res. Counc. Lond. Curr. Pap. 451, 67 pp., 1959.

This paper completes a series dealing with the determination of the boundary-layer drag of biconvex wing sections at supersonic speeds with zero heat transfer for a range of thickness-chord ratio (up to 0.1), mainstream Mach number (up to 5.0), Reynolds number ($10^6 \sim 10^8$) and transition position. Previous results have been extended and improved by allowing for the interaction of boundary layer and external stream, insofar as the resulting changes in the external pressure distribution modify the skin friction distribution. Calculations have also been made of the effect of incidence (up to 10°) on the boundary-layer drag of a flat plate. The discussion includes an analysis in physical terms of the effects on skin friction and boundary-layer pressure drag distributions of the main parameters investigated and in particular of the changes that accompany increase in Mach number. These changes are shown to be readily related to the changes in local free-stream Mach number distribution and the associated changes in local free-stream density × velocity^2 ($\rho_1 u_1^2$). Tables 1-4 present the detailed results and Figs. 9 and 27 summarize the effects of thickness-chord ratio and incidence on boundary-layer drag.

From authors' summary by M. Finston, USA

4099. Whalen, R. J., Boundary-layer interaction on a yawed infinite wing in hypersonic flow, *J. Aero/Space Sci.* **26,** 12, 839–841 (Readers' Forum), Dec. 1959.

4100. Inger, G. R., Chemical non-equilibrium effects in the laminar hypersonic boundary layer, AFOSR TN 59-237 (Bell Aircraft Corp. Rep. 7010-6; ASTIA AD 212 007), 132 pp., Mar. 1959.

In view of the importance of dissociation-recombination chemistry of a flowing air mixture to the accurate calculation of aerodynamics design data, such as heat transfer, real gas dynamics research has focused attention on the theoretical study of the chemical nonequilibrium laminar boundary layer. The present report is concerned with the basic foundations of such studies—in particular, some new theoretical representations of a dissociating air mixture and a new method of nonequilibrium boundary-layer solution are presented.

The general governing conservation equations and attendant boundary conditions are given and discussed. The associated laminar boundary-layer equations are presented, along with a consideration of the proper definition of a characteristic parameter with which the chemical nonequilibrium in the layer can be classified. Three main new features of the problem area are considered. First, an evaluation of the comparative merits of various types of schemes approximating a dissociated air mixture is given and then a more accurate and general method is proposed and developed. This new scheme is applicable to a four-specie air mixture which is in a general state of chemical nonequilibrium. Second, the boundary-layer nonequilibrium stagnation point similarity solution is reformulated in more accurate fashion according to this more accurate air mixture representation, and errors incurred by the use of a lumped "air atom-air molecule" binary approximation of air are discussed. Third, a new method of solving the nonequilibrium boundary-layer problem is discussed, based on a chemical perturbation analysis from either frozen or thermostatic equilibrium extremes. The method permits evaluation of nonequilibrium effects over a much wider set of local conditions than is permitted by a similarity-type solution.

From author's summary by R. Cess, USA

4101. Dommett, R. L., On similar solutions of the boundary layer equations for air in dissociation equilibrium, *J. Roy. Aero. Soc.* **64,** 589, 36-37(Tech. Notes), Jan. 1960.

4102. Zinman, W. G., Recent advances in chemical kinetics of homogeneous reactions in dissociated air, *ARS J.* **30,** 3, 233-238, Mar. 1960.

Turbulence

(See also Revs. 4045, 4086, 4087, 4094, 4215, 4256, 4257, 4268, 4335, 4339)

4103. Kraichnan, R. H., The structure of isotropic turbulence at very high Reynolds numbers, *J. Fluid Mech.* **5,** 4, 497-543, May 1959.

A new theory of homogeneous turbulence has recently been developed by the author [AMR **12**(1959), Rev. 382]. In the present paper the foundations of the theory are recapitulated and an approximation is used to examine the energy dynamics and the spectral structure in case of stationary turbulence. The results are fully discussed and comparisons are made with available experimental data as well as with other theories.

The velocity field is expanded in a Fourier series. The fundamental restriction imposed on the flow is that the statistical dependence among the amplitudes of the Fourier components be induced wholly by the nonlinear terms of the Navier-Stokes equation. This condition, called "maximal randomness," and the properties of the Navier-Stokes equation lead to the "weak dependence principle." The content of this principle is that the dynamical coupling between two individual Fourier amplitudes corresponding to different wave vectors is very weak when the flow volume is very large. This property makes it possible to develop new perturbation expansions, which seem to be useful at all Reynolds numbers. In this way formally complete equations for the covariance tensor are obtained. With regard to the application of the theory to the problems of the present paper the third-order moments are approximated by their lowest terms. This procedure is termed direct-interaction approximation.

The most striking result of the investigation is the solution for the energy spectrum $E(k)$ in the inertial subrange, which is found to be of the form $E(k) \propto (\varepsilon \nu_0)^{1/2} k^{-5/3}$, where k is the wave number, ε the rate of energy dissipation per unit mass, and ν_0 is the root mean square of the velocity fluctuation. This form is at variance with that obtained from the theory advanced by Kolmogorov, Prandtl, Onsager, and v. Weizäcker, which is based on the notion that the energy transfer among the larger wave numbers is affected by the energy content of the large-scale motion. The variation of the spectrum function with wave number is not substantially different for the two theories (according to Kolmogorov's theory the spectrum varies as $k^{-5/3}$). Author finds experimental results in slightly better agreement with his theory than with Kolmogorov's theory. But it seems impossible to decide, on the basis of the available experiments, which of the two theories comes closer to the actual dynamics of turbulent flow. Author suggests that the experimentally observed unevenness in the energy distribution associated with the large wave number components may conflict with the ideas underlying the Kolmogorov theory.

A full account of the basic theory will be given elsewhere. A generalization seems possible to cases in which there is homogeneity in only one or two directions, which actually include the most of turbulent flows of practical interest. Reviewer believes that the theory provides a remarkable contribution to the solution of the turbulent flow problem. Reports on the further development and application will be awaited with great interest.

J. C. Rotta, Germany

4104. Ogura, Y., A note on the energy transfer in Burgers' model of turbulence, *J. Meteorol. Soc., Japan* **75** (Anniversary Vol.), 92-94, Nov. 1957.

Following W. H. Reid, the evolution of "turbulence" in Burgers' one-dimensional model is calculated, assuming also that fourth-order mean values are related to second-order mean values as they would be in a normal probability distribution. The mathematical consistency of these hypotheses is not proved.

G. Birkhoff, USA

4105. Businger, J. A., A generalization of the mixing-length concept, *J. Meteorol.* **16,** 5, 516-523, Oct. 1959.

An analysis is made of the velocity profile of a wind near the surface of the earth which is of some interest to meteorologists. It is essentially a turbulent boundary-layer problem but complicated by the effect of temperature gradient on the flow. The present analysis is based on a generalization of mixing-length theory to take the temperature gradient into account. The result is compared with experiment by plotting quantities involving temperature and velocity gradients, and the agreement seems reasonably good.

W. Squire, USA

4106. Ber, L. E., On a method for solving problems of non-isothermal turbulent convection in a channel formed by parallel planes, *Soviet Phys.-Tech. Phys.* **4,** 1, 52-60, July 1959. (Translation of *Zh. Tekh. Fiz., USSR* **29,** 1, 61-69, Jan. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

This paper displays a number of empirical calculations of mean velocity and temperature distribution in turbulent channel flow, based on Reynolds' analogy and simple expressions for an eddy viscosity. The paper adds little to the many calculations that have been done along these lines in the past.

I. Proudman, England

4107. Lemekhov, E. E., The steady turbulent motion of a gas in a circular pipe (in Russian), *Vestn. Leningrad In-ta* no. 13, 161–168, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8973.

An attempt is made, founded on the semi-empirical theory of turbulence, to establish a relationship between friction and heat transmission in the motion of a gas along a circular pipe, depending on the Prandtl number and the temperature gradient. It is shown that these quantities are not appreciably influenced by the value of the Prandtl number. Curves are presented giving the relationship between the friction and temperature gradient, and the Reynolds number for different values of the Prandtl number.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR

4108. Townsend, A. A., The analysis of temperature fluctuations by pulse-counting techniques, *J. Fluid Mech.* **6,** 2, 261–271, Aug. 1959.

Since it was necessary for the investigation of temperature fluctuations over a heated horizontal plane to measure average values over intervals of more than 10 minutes, an electrical system was developed that uses the counting of electrical pulses generated at a rate proportional to the quantity being investigated. By modulating the amplitude of the pulses, e.g., the square of the quantity or the product of two quantities can be obtained. If the mean values are desired, the modulated pulses are used to charge a condenser. Other circuits for the measurement of the statistical distribution and of the time-derivative of the fluctuations are described. Details of the circuits and block diagrams are given; errors involved with the methods are discussed.

Margot Herbeck, Germany

4109. Tepaks, L. A., The boundary conditions of a turbulent flow along a rough wall (in Russian), *Trudi Tallinsk. Politekhn. In-ta* **A,** 78, 28 pp., 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8974.

An investigation of the transformation of the known relationships for the circulation of a turbulent flow near a wall, founded on the formal substitution of the fluid viscosity by the turbulent viscosity ε. Various empirical formulas for the resistance of smooth and rough pipes are compared, and the possibility is examined of dividing the expressions for the latter from those for the former on the assumption that, in the case of a rough wall, the value of ε is constant within the limits of a thin layer next the wall, and is determined by the dynamic velocity and the geometric proportions of the protuberances. Applying available experimental data, an analysis is made of the relationship between resistance, turbulent viscosity, and surface roughness.

B. A. Fidman

Courtesy Referativnyi Zhurnal, USSR

Aerodynamics

(See also Revs. 3818, 4040, 4044, 4053, 4054, 4055, 4066, 4073, 4085, 4091, 4093, 4096, 4148, 4149, 4176, 4186, 4273, 4274, 4282, 4313, 4339)

4110. Landrum, Emma Jean, Effects of a lower surface jet on the lift-drag ratio of a 45° sweptback wing at a Mach number of 2.01, NASA TN D–183, 40pp., Mar. 1960.

The effects of jet interference were determined for an angle-of-attack range from -2° to 7° for various jet deflections inclined toward the trailing edge. The Reynolds numbers were 1.5×10^6 and 2.8×10^6 based on the mean aerodynamic chord. Improvements in lift-drag ratio were obtained at and near maximum lift-drag ratio. Most effective jet inclinations appear to be those ejecting nearest the vertical, with decreasing effectiveness as the jet is inclined rearward.

From author's summary

4111. Taylor, R. T., An experimental investigation to determine the effect of speed-brake position on the longitudinal stability and trim of a swept-wing fighter airplane, NASA TN D–246, 46 pp., Feb., 1960.

A 0.10-scale model of a swept-wing fighter airplane was tested in the Langley high-speed 7- by 10-foot tunnel at Mach numbers from 0.60 to 0.92 to determine the effects of adding underfuselage speed brakes. The results of brief spoiler-aileron lateral control tests also are included. The tests show acceptable trim and drag increments when the speed brakes are installed at the 32.71-inch fuselage station.

From author's summary

4112. von Karman, T., Some significant developments in aerodynamics since 1946 (The first Daniel and Florence Guggenheim Memorial Lecture), *J. Aero/Space. Sci.* **26,** 3, 129–144, 154, Mar. 1959.

In the introductory section of this Memorial Lecture an interesting account is given of Daniel Guggenheim's influences on the development of the aeronautical sciences by the formation of many research laboratories, by generously supporting several educational establishments and by inducing the author to leave Europe and to establish himself as a leader of aeronautical research in the United States in the 1920's. The Daniel Guggenheim Fund for the Promotion of Aeronautics was established in 1926 and is now being administered by Harry F. Guggenheim, the son of the founder. The First International Congress for the Aeronautical Sciences, at which this paper was presented, was initiated by Harry F. Guggenheim and supported financially with money from the Guggenheim Fund.

The technical part of the paper reviews some recent research developments and briefly draws attention to well-known advances made by the author and other scientists in aerodynamic knowledge. Reference is made to significant developments in research on wing theory, slender wings and bodies, interference effects between component parts of aircraft, nonlinear theories and higher-order approximations, transonic flow, hypersonic flow, boundary-layer theory of turbulence. A long list of references is included.

Reviewer believes this paper to be a valuable record of aeronautical progress and a useful source of information on the current state and trends of aerodynamic research.

W. P. Jones, England

Book—4113. Krassnov, N. F., Aerodynamics, Part 2: Some problems in applied aerodynamics (in Russian), *Mosk. Vyssh. Tekhn. Uch-shche,* 1954, 282 pp.; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8540.

Problems in applied aerodynamics relating to wings and bodies of rotation are discussed. Using experimental data and elementary analytical methods founded principally on the theory of linearization, practical approximations are given for determining the coefficients of head drag, lift and longitudinal moment, for bodies of rotation, elementary wings, and finned bodies at low and high speeds. Problems of wing fuselage interaction are not dealt with.

S. M. Belotserkovskii

Courtesy Referativnyi Zhurnal, USSR

4114. Squire, H. B., A family of camber lines for subsonic applications (modified form of the NACA family with uniform loading over the forward part and linear loading over the rear part), Aero. Res. Counc. Lond., Curr. Pap. 437, 8 pp., 1959.

Camber lines (or mean lines) presented have loadings very nearly the same as the NACA family, but have the practical advantage of being straight near the trailing edge. This is achieved by calculation for finite though small design loading at the trailing edge followed by a simple geometrical modification.

Ordinates are tabulated for camber lines to give uniform loading to 0, 10, 20, 30, 40, 50 or 60% chord. (Suitable thickness distri-

butions are given by R. C. Pankhurst and same author in Aero. Res. Counc., Lond. Curr. Pap. 80, 1950.)

E. P. Sutton, England

4115. Cabot, L., and Guiraud, J.-P., Pressure distribution on a delta wing with elliptic cross section (in French), *Rech. Aéro.* no. 62, 3–5, Jan.-Feb. 1958.

The pressure distributions on a thin delta wing of open angle 60° with elliptic spanwise section and parabolic chordwise section, set at zero incidence in a uniform supersonic stream of Mach number 1.1, is determined theoretically by the method of R. T. Jones [NACA Rep. 835, 1946] and G. N. Ward [*Quart. J. Mech. Appl. Math.* **2**, 1, 74–97, 1949; AMR **3**(1950), Rev. 529]. It is also measured experimentally in the transonic tunnel at La Courneuve. Reasonable agreement between theory and experiment is obtained. Theoretical results are good near the leading edge, where the pressure is determined by first calculating the velocity field and then using the exact Bernoulli equation for the pressure.

M. Holt, USA

4116. Cooke, J. C., The centre section shape of swept tapered wings with a linear chordwise load distribution, Aero. Res. Counc. Lond. Curr. Pap. 470, 28 pp., 1960.

The method of Weber is used to find the shape of the center section of a swept tapered wing to produce a load distribution which changes linearly from unity at the leading edge to zero at the trailing edge along any chord. An approximation for this distribution is used in order to make the integrals tractable. These integrals are evaluated and the downwash calculated. A reasonably accurate approximate formula for the downwash is derived, and the results are illustrated by a few examples, giving downwash and angles of twist.

From author's summary

4117. Rainey, R. W., Working charts for rapid prediction of force and pressure coefficients on arbitrary bodies of revolution by use of Newtonian concepts, NASA TN D-176, 36 pp., Dec. 1959.

An engineering approach has been presented in this paper in order to find aerodynamic characteristics of arbitrary bodies of revolution at supersonic and hypersonic speeds. The approach consists of modified Newtonian concepts in fluid dynamics which assert that the change in the normal components of momentum of the flow are converted into an increment in pressure. The results are presented in the figures from which aerodynamic characteristics can be obtained without any integration of pressure distribution. For everyone who is familiar with the enormous difficulties of mathematical nature by determination of acting aerodynamic forces on the body, this paper presents a good and very useful tool in dealing with aerodynamic forces.

M. M. Stanisic, USA

4118. Sheppard, L. M., Supersonic estimation of the wing incidence equivalent to a camber distribution, Austral. Defence Scient. Service, Weapons Research Establishment TN HSA 53, 8 pp., Oct. 1959.

Two-dimensional supersonic airfoil theory has been used to determine the lift increment associated with a camber distribution. This lift increment was found to be proportional to the product of camber ratio and thickness ratio. The equivalent wing incidence, giving the same lift increment, can be calculated directly from the lift-curve slope.

Results are given for some simple camber and thickness distributions of the double-wedge, modified double-wedge and parabolic-arc types. Estimates of equivalent wing incidences, which follow from such results by using a strip method, have applications to the stabilizing fins of test vehicles when rolling frequencies have to be predicted.

From author's summary

4119. Centolanzi, F. J., Measured and theoretical flow fields behind a rectangular and a triangular wing up to high angles of attack at a Mach number of 2.46, NASA TN D-92, 77 pp., Sept. 1959.

Measurements were made of the flow field behind a rectangular and a triangular wing of aspect ratio 2 up to angles of attack of 30°. Tests were performed at a Mach number of 2.46 and a Reynolds number of 3.12 million per foot. The downwash, sidewash, Mach number, and dynamic pressure in the wakes of both wings are compared with the predictions of various theoretical methods. The results show that for angles of attack up to 20° these flow quantities can be calculated with sufficient accuracy for most engineering purposes.

J. V. Becker, USA

4120. Kennet, H., and Ashley, H., Forces and moments on oscillating wind-body combinations at supersonic speed, *J. Aero/Space Sci.* **26**, 9, 605–606 (Readers' Forum), Sept. 1959.

Note gives summary of some of the results contained in two papers with above title: Part I, "Basic theory" by Zartarian and Ashley [AMR **11**(1958), Rev. 2218] and Part II "Applications and comparison with experiment" by Kennet, Ashley and Stapleford [OSR TN 58-114, MIT Fluid Dynam. Group Res. Rep., Dec. 1958]. Treatment is by linearized theory. Comparison of theory and experiment for static stability and fixed-axis damping in pitch shows good agreement.

G. N. Ward, England

4121. Salaun, P., Unsteady theoretical aerodynamic coefficients in subsonic flow for a wing with low aspect ratio (in French), *Rech. Aéro.* no. 65, 29–34, July/Aug. 1958.

Paper gives a condensed account of author's work on oscillating wings of small aspect ratio in subsonic flows, which is to be published in detail as an ONERA Tech. Memo. The method used is an extension of that of Lawrence and Gerber [see AMR **6**(1953), Rev. 534] for the similar problem in incompressible flow. Wing planforms are limited to those with straight trailing edges perpendicular to the free stream. With applications to elastic wings in mind, the effects of full-span "ailerons" are also considered. Some numerical results for 60° delta wings are given, and further results are promised in the more detailed Tech. Memo.

G. N. Ward, England

4122. Licher, R. M., Calculation of the thickness and radial force distribution for a ring wing having zero drag at supersonic speeds, Douglas Aircr. Co. Rep. SM-23579, 22 pp., May 1959.

Linearized compressible flow theory is applied to calculate the shape and pressure distribution for a set of cylindrical ring wings that have zero wave drag. The results are obtained by application of a simple and interesting method in which a pair of paralled Mach planes of infinitesimal strength and opposite sign are rotated about an axis parallel to the free stream. This method is useful for some other problems as well, and an appendix is included in which results are presented of an application to a cylindrical configuration with nonvanishing base area and pitching moment.

J. R. Spreiter, USA

4123. Mangler, K. W., and Randall, D. G., Calculation of the load distribution over a wing with arbitrary camber and twist at sonic speed, Aero. Res. Counc. Lond. Rep. Mem. 3102, 46 pp., 1959.

A method is presented for calculation of load distribution due to camber and twist over a thin wing for which $A^2(M^2 - 1)$ is small, A being aspect ratio and M free-stream Mach number, assuming linearized potential flow. Resulting integral equation is solved numerically for general planform. Simple examples show effect of twist and camber on load distribution and on suction force along leading edge of delta wing. Family of linearly twisted wings with straight-edged planforms is considered in some detail. Results obtained, and those obtained in previous work for same family of planforms at incidence, are plotted against three parameters: A,

$(1-\lambda)/(1+2)$, where λ is taper ratio, and $A \tan \Delta_{1/2}$, where $\Delta_{1/2}$ is sweepback angle of half chord line.

From authors' summary by A. Balloffet, USA

4124. Biriukov, E. A., The downwash of the flow behind the swept vortex of finite span for non-laminar motion, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 3, 823–826, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Article develops a method of calculation of downwash velocities and angles of attack behind a wing of large aspect ratio and small angles of sweep in an incompressible ideal fluid. The solutions for the velocities are based on Biot-Savart law, while the spanwise change of the circulation is assumed to be harmonic. Obtained are expressions for downwash velocity amplitudes and for the lag of downwash.

G. A. Tokaty, USA

4125. Wood, A. D., Brief experiments on a flapped aerofoil having a cusped cavity and a blowing jet at the cusp, Nat. Res. Counc., Canada, LR-269, 19 pp., Dec. 1959.

Experiments on a simple flapped airfoil incorporating a cusped cavity and having a blowing jet at the cusp show that it is possible to produce a flow regime in which the cavity is occupied by a stable trapped vortex. With the airfoil immersed in a quasi-two-dimensional finite stream, greater rotation of the resultant force vector was obtained with a flap of this type than with a flap having no cavity. The results indicate that the combination of a blowing jet and a trapped vortex may be used to advantage in enabling an external flow to overcome an adverse pressure gradient.

From author's summary

4126. Thomas, H. H. B. M., and Mangler, K. W., All-moving wing-tip controls at subsonic, sonic, and supersonic speeds. A discussion of available theoretical methods and their application to a delta wing with half-delta controls, Aero. Res. Counc. Lond. Rep. Mem. 3086, 64 pp., 1959.

Paper contains theoretical methods for calculating the performance or all-moving wing-tip controls at subsonic, sonic and supersonic speeds. The wings are assumed to be thin, and viscous effects and the shock waves formed at transonic speeds are neglected. The theory is developed from that given by Multhopp for subsonic speeds and Mangler for sonic speeds; for supersonic speeds, linearized theory is used. Although it is relevant to other planforms, the theory, in the form presented, is directly applicable to planforms whose spanwise section consists of one segment only. The case of half-delta controls on the tips of delta wings is studied in detail.

Calculated values for half-delta controls on a 60-degree delta wing are compared with free-flight measurements of rolling moment and hinge moment made by the N.A.C.A. for Mach numbers between 0.5 and 1.5. There is good agreement between the trends of the calculated and measured results; the discrepancies between the absolute values are ascribed mainly to the effects of viscosity, of gaps at the control roots, and of geometrical differences between the configurations considered in the theory and experiment.

Authors conclude that the theoretical methods should be of value in design studies, or in selecting configurations for detailed experimental investigation.

D. W. Holder, England

4127. Iserland, K., Investigation of the reversal of a free air jet by swirl (in German), ETH Zurich, Promotionsarbeit 2810, 99 pp., 1958.

The method of thrust reversal discussed in this report is based on the following principle: A guide wave system upstream of the nozzle gives the jet a rotational velocity component or swirl so that it spreads radially and is caught and reversed by a ring-cascade situated downstream of the nozzle exit and outside the rim of the nozzle.

Detailed model experiments are described. They show that if the rotation is gradually increased the jet is not caught by the ring cascade until the rotation reaches a critical value. A sudden spreading then occurs leading to complete reversal. This phenomenon is due to a sudden change in the structure of the jet as the ambient air enters the core of the jet which then becomes annular and spreads rapidly.

Above the critical rotation it was also found possible to achieve reversal by suction at the rounded nozzle outlet without using a ring cascade.

Paper gives large number of graphs showing jet structure, thrust, etc., as affected by the rotation and other variables.

N. H. Johannesen, England

4128. Dickey, R. R., and Levy, L. L., Jr., The effect on the drag of a wing-body combination of moment-of-area-rule modifications with pods ducted to simulate engine nacelles, NASA TN D-308, 15 pp., Feb. 1960.

The zero-lift drag of a basic wing-body combination with an elliptic-planform wing of aspect ratio 3.0 and of the basic model with two separate moment-of-area-rule modifications was measured at Mach numbers from 0.6 to 1.4. The two modified models were identical except that the inboard pods of one of the models were ducted to simulate engine nacelles with internal-compression-type inlets.

From authors' summary

4129. Grant, F. C., Importance of the variation of drag with lift in minimization of satellite entry acceleration, NASA TN D-120, 22 pp., Oct. 1959.

The use of realistic drag polars leads to lower peak accelerations than those obtained on the assumption of constant drag coefficient. Numerical calculations are presented for an entry vehicle with a simplified but realistic complete drag polar.

From author's summary by A. N. Petroff, USA

4130. Graham, E. W., and Beane, B. J., The use of artificial singularity distributions to find minimum drag for fixed base area in supersonic flow, Douglas Aircr. Co. Rep. SM-23698, 15 pp., Sept. 1959.

This report considers the application of the method of artificial singularities to the problem of finding minimum thickness drag in supersonic flow, subject to the constraint of fixed base area. No further limitations are imposed other than those inherent in linearized theory. A suitable artificial singularity distribution employing sources as well as lift and side-force elements is described. The method is illustrated for the special example of a Mach envelope rim which lies entirely in one plane, the plane being swept with respect to a normal to the free-stream direction. For wings or wing-body systems that correspond to the prescribed Mach envelope rim, the minimum value of supersonic wave drag under the restriction of fixed base area is found. Extension of the method to more general cases where the Mach envelope rim does not lie in a single plane also is indicated.

From authors' summary by M. Epstein, USA

4131. Strand, T., Design of missile bodies for minimum drag at very high speeds—thickness ratio, lift, and center of pressure given, *J. Aero/Space Sci.* **26,** 9, 568–570, Sept. 1959.

For hypersonic flow the pressure coefficient depends only on the angle between the free-stream velocity and the local normal to the body. Modified Newtonian theory gives a corrected coefficient for C_p. In the present paper unmodified coefficient $C_{p\,max} = 2$ is used, and a hemisperical nose is assumed. Drag coefficient computed for this nose is $C_D = 1$. Analysis is restricted for angles of attack smaller than the smallest body slope. Calculated drag and lift values should be scaled down by the ratio $C_{P_{max}}$ to 2. From the expression for the total body drag, including the drag of hemisphere, for all bodies of revolution of specified type, a shape for

minimum drag is obtained using the calculus of variation; this optimum shape is not a function of lift but depends on the center of pressure location. The way to design bodies of revolution with a minimum variation of center of pressure with lift is also shown, and a corresponding drag penalty for such body compared to absolute minimum drag body is computed.

P. Bielkowicz, USA

4132. Williams, D., Drag force on a golf ball in flight and its practical significance, *Quart. J. Mech. Appl. Math.* **12,** 3, 387-392, Aug. 1959.

A generalization is reached for the drag law of a golf ball, based on some results obtained for impact distances (carry) for a particular range of initial drive velocities. The author rejects the implication that the method he presents is approximate but data is lacking to assess experimental accuracy. The conclusion is reached that drag varies only as the first power of velocity. In reviewer's opinion, this depends on the nice mathematical solution in which carry versus initial velocity is taken as a straight line, rather than a different function of velocity, and also on the assumption that initial and impact trajectory angles do not vary. Further calculation yields the result that a long driver gains an advantage of 17% in distance because of drop in drag coefficient.

H. M. Spivack, USA

4133. Schmidt, W., Body of revolution with small wave drag at zero angle of attack at near sonic and high supersonic speeds(in German), Z. *Flugwiss.* **7,** 7, 194-201, July 1959.

Author calculates the drag coefficient of forebodies of revolution of minimum wave drag, or the so-called Sears-Haack bodies. These are slender bodies with cross-sectional areas expressible as polynomials in the axial coordinate. It is pointed out very strongly that the formulas for the calculation of minimum wave-drag bodies are, strictly speaking, valid only for the vanishing thickness ratio ($\tau \longrightarrow 0$). For the finite thickness ratio and for the increasing Mach number the flow fields calculated under the assumption of $\tau \longrightarrow 0$ are more or less inaccurate. For this reason in the subsequent chapters author takes into account the influence of finite thickness-ratio and of larger supersonic Mach numbers upon the flow pattern and wave drag. Calculations show a very strong influence of the Mach number upon the drag coefficient. The first approximations are calculated for $M_\infty = 2\ ^1/_4$, the second refer to $M_\infty = 5\ ^1/_4$. Results indicate the necessity for calculations of higher-order approximations with an additional source distribution in order to fulfill the boundary conditions at the surface. Application of the source distribution, used in the first approximation, for the calculation of higher-order approximation may result in considerable changes of the contour. This justifies the use of additional sources. A comparison of the results for two Sears-Haack bodies indicates a decrease in drag coefficients with increasing Mach number. A body with a smaller wave-drag coefficient in the first approximation shows also smaller wave-drag coefficients in the second approximation as compared with another body.

M. Z. v. Krzywoblocki, USA

4134. Graham, M. E., and Ryan, S. M., Trim drag at supersonic speeds of various delta-planform configurations, Douglas Aircr. Co. Rep. SM-23635, 96 pp., July 1959.

The drag due to lift and the maximum lift-to-drag ratio at supersonic speeds of zero-thickness, trimmed, statically stable (1) delta-wing-plus-tail, (2) delta-wing-plus-canard, and (3) delta-wing-alone configurations are studied with the aid of linear theory. In general it is found that the drag due to lift decreases and the maximum lift-to-drag ratio increases as the aspect ratio increases, the vertical gap increases, the "tail length" increases and the static margin decreases; also suitable camber and twist decrease the drag. However, calculations for wing-with-flap configurations indicate that if full leading-edge thrust exists there is a range of aspect ratio in which decreasing the aspect ratio decreases the drag due to lift. Also if leading-edge thrust exists, or if the surfaces are twisted and cambered there can sometimes be less drag due to lift at a small positive static margin than at zero static margin. There is little difference between wing-canard and wing-tail configurations at cruise conditions if the gap is not too small. If the gap is small, the lift-drag ratio of the wing-canard configuration becomes poorer than that of the corresponding wing-tail configuration unless the wing of the canard configuration is suitably twisted. At moderate static margins there is little difference between trimmed flat wing-flap configurations and flat wing-plus-tail or wing-plus-canard configurations with not too small gaps. At large static margins the lift-drag ratio of the wing-flap configuration is poor compared to the wing-tail or wing-canard configurations of not too small gap unless the wing is suitably cambered and twisted. From this investigation it appears that the choice of a type of trim surface (tail, canard or flap) will depend primarily upon considerations other than supersonic cruise performance.

From authors' summary by M. Epstein, USA

4135. Heath, A. R., Jr., Longitudinal aerodynamic characteristics of a high-subsonic-speed transport airplane model with a cambered 40° sweptback wing of aspect ratio 8 at Mach numbers to 0.96, NASA TN D-218, 88 pp., Feb. 1960.

The longitudinal characteristics of a complete high-subsonic-speed transport configuration with a cambered wing have been measured. The wing was cambered for a lift coefficient of 0.514, had a taper ratio of 0.3, and had NACA 65A-series airfoil sections. Modifications to the model, such as changes in the fuselage shape, leading-edge extensions on the wing, special wing bodies, and lower-surface ridges on the wing, were investigated to determine the effects on the longitudinal stability and maximum lift-drag ratio. The investigation covered a Mach number range from 0.40 to 0.96.

From author's summary

4136. Fournier, P. G., Low-speed investigation of static longitudinal and lateral stability characteristics of an airplane configuration with a highly tapered wing and with several body and tail arrangements, NASA TN D-217, 46 pp., Jan. 1960.

Results are presented of the static longitudinal and lateral stability characteristics of a low-speed investigation of an airplane configuration with a three-body arrangement and a highly tapered wing with its 0.80-chord line unswept and with several tail arrangements as well as a conventional single-fuselage model with the same wing. The wing had a taper ratio of 0, an aspect ratio of 4, and an NACA 65A004 airfoil section. The data show that for the three-body model all tail-on configurations were directionally stable throughout the angle-of-attack range and were greatly improved over the conventional model configuration.

From author's summary

4137. Conlin, L. T., and Orlik-Ruckemann, K. J., Comparison of some experimental and theoretical data on damping-in-roll of a delta-wing body configuration at supersonic speeds, Nat. Res. Counc., Canada, LR-266, 16 pp., Dec. 1959.

The damping-in-roll derivative of a wing-body combination consisting of a triangular wing of aspect ratio 2 and a body of revolution, with and without a fin, was measured at two oscillation frequencies using the free oscillation technique. The results were compared with theory and other experiments in wind tunnel and aeroballistics range.

The damping-in-roll derivative ($-C_{l_p}$) was found to decrease with increasing supersonic Mach number and increase with increasing frequency. The accuracy with which the damping-in-roll for such a configuration can be predicted by linearized theory for the isolated triangular wing was found to decrease with increasing

Mach number. However, the theory seems to predict correctly the effect of aspect ratio. The results of wind-tunnel and aeroballistics-range tests show good agreement.

From authors' summary

4138. Mabey, D. G., The rolling moments due to sideslip on high tailplanes at subsonic and transonic speeds, *J. Roy. Aero. Soc.* **64,** 591, 161–163 (Tech. Notes), Mar. 1960.

4139. Orlik-Ruckemann, K., Methods of measurement of aircraft dynamic stability derivatives, Nat. Res. Counc., Canada, Aero Rep. LR-254, 37 pp., July 1959.

Author collects an extensive bibliography and groups together the available methods of measurement of aircraft dynamic stability derivatives in a particular way. Schematic drawings illustrate main ideas. List covers fairly well both past and present activities in this field. G. A. Magony, USA

4140. Hamer, H. A., and Mayer, J. P., Power spectral analysis of some airplane response quantities obtained during operational training missions of a fighter airplane, NASA TN D-366, 41 pp., Mar. 1960.

Power spectra of normal and transverse load factor and pitching acceleration are presented for several types of missions normally performed by the airplane. The frequency content, which is described by the spectrum, provides information which is useful in control-system design and in the design of recording and computing equipment for analyzing maneuver-load data. The normal-load-factor data were found to exhibit some to the characteristics of a Gaussian random process; therefore, peak distributions for this quantity could be estimated to a good degree of accuracy with the use of spectrum-analysis methods.

From authors' summary

Vibration and Wave Motion in Fluids

(See also Revs. 3822, 3833, 3927, 4062, 4063, 4065, 4094, 4148, 4279, 4289, 4312, 4370, 4372, 4373)

4141. McCaig, I. W., and Jonker, F. H., Applications of computer and model studies to problems involving hydraulic transients, *ASME Trans.* **81** D (*J. Basic Engng.*), 4, 433–445, Dec. 1959.

For certain cases of water-hammer problems the standard stepwise graphical or analytical solutions become very tedious and digital computers can be used to advantage. Authors illustrate this with a Canadian power station with multiple turbines and penstocks, a long supply tunnel and surge tanks. Computer speeds permit rapid evaluation and comparison of various types of surge tanks. Analog computers are also useful when such problems as surge tank stability and tank drainage are being considered. Authors also discuss hydraulic modeling, the scaling laws that must be observed, and how such models can be used for water-hammer studies. E. G. Chilton, USA

4142. Kleiman, Ia. Z., On the method of characteristics in the theory of motion of a multicomponent medium, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 2, 551–555, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

This paper represents a continuation of author's study of multiphase media [see AMR **12** (1959), Rev. 4000]. $2n$ unsteady, one-dimensional continuity and momentum equations of an n-component mixture are written for plane, cylindrically symmetrical, and spherically symmetrical systems. Assuming that each of the n fluids is barotropic, a closed set of equations is obtained for the mass fraction, density, and velocity of each component, and pressure (a total of $3n + 1$ flow variables). The equations for the characteristic surfaces and for the change of flow variables along these surfaces are derived. It is shown that, for a binary mixture, unless the relative velocity of the two components exceeds sound velocity, only two of the four characteristics are real. Hence the ordinary method of characteristics is usually not applicable to multiphase mixtures. F. A. Williams, USA

4143. Kampe de Feriet, J., Statistical mechanics of two-dimensional waves with finite energy, David W. Taylor Mod. Basin Rep. 1230, 21 pp., Oct. 1958.

By replacing phase space with functional L^2 space, so that the state of a continuum is defined through a set of proper functions, a statistical mechanics of continuum can be formulated strictly following the outline of classical Gibb's statistical mechanics. In this case one considers random integrals (corresponding to random initial values) of the partial differential equation governing the motion. The randomness is introduced through proper probability measures on L^2.

This formalism was applied to the study of two-dimensional gravity waves with finite energy. H. S. Tan, USA

4144. Snegirev, I. A., Velocity pulsation at a junction (in Russian), *Gidrotekh. Stroit.* **28,** 2, 41–42, Feb. 1959.

A series of 20 measurements was performed on bucket-type stilling basin, the pulsations being recorded by filming. The pulsations of bottom velocity (the term is not defined sufficiently) can reach 50% of the mean local velocity in case of two-dimensional flow, while in the case when the width of stilling basin is less then the tailwater channel width this pulsation can be much greater. M. M. Boreli, Yugoslavia

4145. Gladkikh, P. A., and Maksutov, R. A., The extinction of oscillations due to pressure surges of liquids in pipelines (in Russian), *Novosti Neft. Tekbn. Neftepereabotka* no. 6, 20–24, 1957; *Ref. Zh. Mekb.* no. 8, 1958, Rev. 8739.

In order to reduce pressure oscillations in pipelines it is usual to install air vessels directly on or next to the pumps. To obviate the risk of explosion as well as loss of air from such air vessels, it is recommended that they be connected to pressure oil pipelines by intermediate sleeves filled with a medium which does not absorb or dissolve air. Full-scale tests made with electric strain-gage equipment have resulted in the following: (1) The magnitude of the amplitude of oscillation of pressure surges in pipelines connected to a reciprocating force-pump plant depends on the value of the mean pressure. The amplitude of oscillation of the pressure surges considerably increases in the presence of a local hydraulic resistance at the end of the pipeline. (2) Extinction of pressure surges by means of an air vessel is attained over the whole length of the pipeline between the pump and the local hydraulic resistance (heat-exchanger, cooler, etc.) independently of the point of location of the air vessel. (3) The amplitude of oscillation of the pressure surges in a pipeline in the presence of an air vessel is practically constant with increasing mean pressure.

M. E. Faktorovich
Courtesy Referativnyi Zhurnal, USSR

4146. Gade, H. G., Effects of a nonrigid, impermeable bottom on plane surface waves in shallow water, *J. Mar. Res.* **16,** 2, 61–82, 1958.

Mutual effects of progressive wave motion in shallow water and in underlying fluid sediments are discussed, with emphasis on modification of the surface wave. The mathematical model is a layer of inviscid fluid overlying a viscous fluid of greater density and bounded by a horizontal rigid plane. Solutions for locally periodic, simple harmonic disturbances indicate that wave height decays exponentially with travelled distance. It is found that the

rate of decay has a maximum value when the dimensionless parameter $b_0 (\sigma/2\nu)^{\frac{1}{2}}$ has a value of 1.2, σ being the angular frequency, ν the viscosity, and b_0 the thickness of the lower layer.

The rate of dissipation of energy in the lower layer is found to be proportional to (a) the wave energy, (b) the ratio of amplitudes at the interface and the surface, and (c) the sine of an angle closely related to the phase difference between profiles at the free surface and the interface. Comparison is made between typical values of wave decay due to dissipation in a fluid bottom and that due to friction loss over a rigid sand bottom. Even in a relatively thin layer of mud the dissipation exceeds by far the energy loss due to bottom friction.

From author's summary by L. R. Mack, USA

4147. Vaughan, V. L., Jr., Water-landing impact accelerations for three models of reentry capsules, NASA TN D-145, 26 pp., Oct. 1959.

Experimental vertical and lateral acceleration data are presented for the water impact of three rigid-body models of reentry capsules, one having a spherical segment bottom, one a 53° conical bottom and the third a convex-concave bottom. The models were dropped in an upright position and at inclination angles of 15° and 30°. Tests were made for both vertical drops and for impact at a 65° flight path angle from the horizontal.

R. F. Smiley, USA

Fluid Machinery

(See also Revs. 3828, 3954, 3970, 4020, 4036, 4043, 4044, 4089, 4148, 4188, 4291, 4302)

4148. Mori, Y., On wakes behind a single aerofoil and cascade, *Bull. JSME* **2,** 7, 463–469, Aug. 1959.

Paper reports experimental study of two-dimensional wakes of airfoil and cascade with small flow deflection (no details given). Profiles tested were NACA 65 series of 3-cm chord and aspect ratio 3. Pitch-chord ratio of cascade was unity. Work was carried out in low turbulence tunnel 9 cm by 30 cm; airspeed 1–40 m/sec. Reynolds numbers were from 10,000 to 70,000.

It was found that boundary layers on surfaces were laminar but that a laminar wake extended for only a short distance downstream of trailing edges. Laminar wake was followed by a transition region which developed into a turbulent wake. Appreciable sinusoidal velocity fluctuations were observed in transition region; frequency of these fluctuations was proportional to 3/2 power of flow velocity for airfoil and cascade.

Sound was generated by cascade but not by single airfoil. For airspeeds above 22 m/sec, strong sound of constant frequency 3.9 kc was observed. For airspeed 25-30 m/sec, frequency of transition region velocity fluctuation was constant 3.9 kc. Above 30 m/sec, frequency of velocity fluctuation again followed 3/2 power of velocity law and strong sound was not generated. Cascade blade resonant frequency was 3.9 kc. Acoustic frequency between adjacent blades was calculated as 3.8 kc. Thus sound generated appears to be due to resonance of transition region velocity fluctuations and acoustic vibration. Measurements indicate that relation between static pressure and velocity fluctuation in transition region requires further investigation.

Although general conclusions are not possible from such a limited investigation, paper will be of interest to people studying noise ge[illegible]n in turbomachines.

R. A. A. Bryant, Australia

4149. Betz, A., Approximate formulas for the conformal mapping of flat-plate airfoil cascades with narrow spacing (in German), *Ing.-Arch.* **28,** 6–12, Mar. 1959.

The conformal mapping of flat-plate airfoil cascade into the half plane yields a transcendental equation for the ralationship between the coordinates of a point on the airfoil section and the corresponding point in the figure plane; the solution of this equation is, especially in the case of narrow spacing, rather complicated. The author, assuming infinitely long sections, derives simple approximate formulas which yield, in the case of narrow spacing, sufficiently accurate results. For larger spacing, a simple correction term for the finite length of the section is to be added.

J. Polasek, Czechoslovakia

4150. Isay, W.-H., Flow through an oscillating and rotating radial cascade (in German), *Z. Flugwiss.* **6,** 11, 319–328, Nov. 1958.

Extension of earlier work [AMR **8** (1955), Rev. 1058] to plane potential flow of an incompressible fluid through a rotating cascade of oscillating line elements. The time dependence of the oscillating movement is assumed to be of such form as to give the same velocity and circulation distribution over each line element. The integral equation for the circulation distribution along the blade is derived under the assumption that the circumferential component of the resulting blade velocity from rotation and oscillating movement varies linearly with radius. From this equation seven complex quantities can be determined, giving an approximate expression for the total circulation over each line element as a function of the angle of rotation. Cases of outward and inward flow are treated separately and some properties of integral equations solutions are given. Numerical results for the total blade circulation of a rotor are presented in a table and in diagrams.

A. Kuhelj, Yugoslavia

4151. Ikui, T., Flow in axial blade, *Bull. JSME* **3,** 9, 29–35, Feb. 1960.

The flow behaviors of the flow field in an impeller and guide vane of axial blower have been observed using the technique of visualization by silk tufts. When the stall zone is limited to the tip region only, the surging zone on the ψ-ϕ characteristics does not appear clearly. Therefore, if the suction or delivery concentric rings have the effect to prevent the stall zone from extending toward the section within geometrical mean radius, the stall characteristics of an axial machine will be improved.

In the stationary guide vane of an axial blower, the blade characteristics are better than those of other section, owing to the flow in the boundary layer from tip to root caused by a secondary flow in the curved channel.

From author's summary

4152. Hopkes, U., Theoretical and experimental cascade flow investigations at high subsonic Mach numbers, AFOSR TR 59–45 (Institute für Aerodynamik der deutschen Forschungsanstalt für Luftfahrt Rep. 59/21; ASTIA AD 214 810), 55 pp., 1959.

Extensive experimental investigations on two-dimensional cascades at high subsonic Mach numbers have been carried out in the Variable Density High Speed Cascade Wing Tunnel of the Deutsche Forschungsanstalt für Luftfahrt, Braunschweig. Varying the cascade geometry and the Mach number the following quantities have been measured up to the choking Mach number for two different blade profiles (NACA 0010 and NACA 8410): pressure distribution on the blade, loss coefficient, deflection of flow and static pressure difference across the cascade. The loss coefficient and the deflection are nearly constant up to the critical Mach number, but the static pressure difference varies with the Mach number. The experimental pressure distributions have been compared with different theoretical methods for calculating pressure distributions in compressible flow.

From author's summary

4153. Dettmering, W., Flow investigations on rotating cascades (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 88–101.

The air flow over co-axial cylindrical surfaces has been investigated experimentally by means of an axial flow turbine cascade, consisting of prismatic blades for stator and impeller. The fields of in-flow and out-flow have been tested at various points and pressure distributions taken over blade sections on stator and impeller separately. For constant geometry of blade section and cascades of stator and impeller, the experimental results give some guidance on the problem of the effect of centrifugal forces on rotating cascades and on the reciprocating effects of the impeller on the stator. For testing the loss in total pressure behind the rotating impeller cascade, a total-pressure probe rotating with the impeller is used. Experimental results for stator and impeller are compared with each other as well as with results for the plane and straight cascade. From author's summary

4154. Kovalev, N. N., Actual state and some aspects on the development of turbine construction in USSR (in Russian), *Gidrotekh. Stroit.* **27,** 11, 35–43, Nov. 1958.

Paper is just a brief report on the most important contributions by Soviet technicians in this field. Author says the greatest turbine in the world today is a Soviet one: the one in Bolshskaya Hydroelectrical Power Plant, which is 9.3 m in diameter and 22.5 m in head and with a power output of 126,000 Kw (the greatest in U.S.A. has a power output of 94,500 Kw). In the near future, he thinks, Russian engineers will be able to build machines that perhaps will attain values of 200,000 or even 300,000 Kw.

Article also contains some useful data concerning additional parts of turbines, such as the servomotors, draft tubes and so on, and gives some suggestions on these based on Soviet experimental results, including new investigation with vertical wheels and Kviatkovsky's test on diagonal-pass turbines.

J. L. Sanchez Bribiesca, Mexico

4155. Rohbach, J., Investigation of clearance losses of turbine stators with rotating clearance wall (in German), Dtsch. Forschungsanstalt Luftfahrt, Ber. 90, 74 pp., 1959.

The end clearance of cascades changes the flow picture by blowing away the low energy fluid in the corners. With the rotative motion of the clearance wall the flow through the gap slows down for turbine and speeds up for pump, both for stator and rotor rows. Simultaneously with careful theoretical formulation, a test machine was built with a single-row axial turbine annular cascade stator (NACA 8410 blades, 702-mm o d) and a cylindrical rotating hub (456-mm o d) rotatable with or without a nose fairing. Tests showed that with usual clearances the effect of the rotation on the clearance losses is small. Similarly, the fairing, flow angle, and solidity of blade row have little influence. Comparative measurements on straight cascades show that clearance losses and the outlet flow angle can be transferred to annular cascades except for great turning angles and pitch.

At usual clearances the mixing losses near the end of the blade agree pretty well with the energy of the secondary flow and are about 1% of the kinetic energy of the exit velocity.

Lines of constant total pressure loss of the exit flow are not radial, an advantage to the following rotor. Pressure and velocity distributions follow the Eckert-equations (radial equilibrium theory) for constant exit angle but the clearance vortex gives additional velocities and static pressures near the hub greater than theoretical, which work there against separation. The tests show that clearance losses expressed as coefficients based on the axial velocity head vary with the 0.21 power of the relative clearances (defined as ratio of clearance to blade chord $s/_l$) from $s/_l = 0.1$ to 0.005, below which they can be considered constant.

A. Hollander, USA

4156. Novelson, M. I., and Shorstyuk, A. N., The modelling of centrifugal fans (in Russian), *Energomashinostroyenie* no. 10, 18–19, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8598.

When the dimensions and running speed of a fan are varied, its pressure coefficient H and hydraulic efficiency η also change. In this regard, the principal influence on the change in H and η is exerted by any change in the dimensions of the fan—a change in the degree of relative roughness. The problem is analyzed of determining the influence of the relative surface roughness Δ on the coefficient H in model fan tests. If the proportion of frictional losses α is known, as well as the hydraulic efficiency of the model η', and the full-scale and model coefficients of friction λ and λ', then the influence of Δ can be evaluated by the formula

$$\frac{H}{H'} = \frac{1}{\eta'} - \left(\frac{1}{\eta'} - 1\right)\left(\alpha\frac{\lambda}{\lambda'} + 1 - \alpha\right)$$

It is demonstrated that the suggested formula satisfactorily coincides with the results of experiment, even if the dimensions of the model differ greatly from the full-scale dimensions.

V. A. Bashkin

Courtesy Referativnyi Zhurnal, USSR

4157. Minami, S., Kawaguchi, K., and Homma, T., Experimental study on cavitation in centrifugal pump impellers, *Bull. JSME* **3,** 9, 19–29, Feb. 1960.

Investigations concerning cavitation in several impellers with three-dimensional blades were carried out using a 200-mm bore single suction pump installed in a closed circuit system. Flow inside the impeller was observed with strobo-light, and the NPSH at the condition of cavitation incipience, measured for each impeller, was found to show a peculiar variation against capacity, taking a minimum at or near the designed flowrate and a peak at a partial capacity. The flow at the impeller inlet was measured with a pitot tube and it was clarified that the flow pattern which accompanied remarkable swirling and back flow at partial capacities was responsible for the above NPSH variation. The cavitation aspects in the impellers are presented by photographs and their correlations with the various local pressure drops are discussed. The impellers were compared in terms of pressure drop coefficients as well as the suction specific speed plotted versus capacities, with a view to applying then to practical fields.

From authors' summary

4158. Serovy, G. K., and Anderson, E. W., Method for predicting off-design performance of axial-flow compressor blade rows, NASA TN D-110, 37 pp., Aug. 1959.

Method of calculating off-design performance of compressor stages is based upon (1) radial equilibrium analysis, including radial variations of entropy; (2) NACA cascade data for blade section exit angles and losses; (3) assumed values for boundary-layer blockage factor, pressure rise, temperature-rise correction factors. Method is applied to calculate performance of two rotor blade rows, one with, one without guide vanes. For examples given, first assumption should be valid, second assumption should be reasonable, but apparent underestimation of blockage factor leads in second example to estimate of pressure rise which is high compared with experimental results.

Paper illustrates that NACA methods for compressor design and performance estimation are useful only if factors listed in (3) above are accurately known. Prediction of stalled performance is not attempted.

J. H. Horlock, England

4159. Scheer, W., Investigations and observations on the performance of axial pumps with special reference to part-load operation (in German), *Brennstoff-Wärme-Kraft* **11,** 11, 503–511, Nov. 1959.

The sudden pressure drop of axial pumps, usually called "stall", is sometimes very troublesome. Author examines how the stall may be influenced by pump design and what can be done to obtain stable operating conditions for part-load also. Based on visual

observations a flow pattern at partial load is presented. It shows that stall and development of an eddy in front of the impeller coincide. From author's summary

4160. Senoo, Y., and Kasai, T., A study of a wet vacuum pump, *Rep. Res. Inst. Appl. Mech. Kyushu Univ.* **7,** 25, 1–14, 1959.

Pump consists of bladed rotor in casing which gives a varying radial clearance. When the casing is partially filled with liquid which flows along casing due to centrifugal action, gas is trapped between blades and compressed when clearance decreases; design pressure ratio is fixed by port design. Experimental data presented on pressures around periphery and similarity conditions are checked. Data for variation of flow rate and work with pressure ratio also are given. Separate analyses of simplified models account for the work done by the rotor on the liquid and by the liquid on the gas; latter is similar to reciprocating compressor with fixed valve openings.

Results indicate some of the reasons for the low efficiency of such machines and for the abnormal behavior of certain machines when operating away from design conditions. Discussion is difficult to follow in places.

S. R. Montgomery, England

4161. Hecker, R., and McDonald, N. A., The effect of axial spacing and diameter on the powering performance on counterrotating propellers, David W. Taylor Mod. Basin Rep. 1342, 50 pp., Feb. 1960.

An investigation of counterrotating propellers was conducted. For this investigation a series of counterrotating propellers was designed and tested in open water. Part of this series was used to investigate the effect of axial spacing on efficiency while another part was used to study the effect of the forward propeller diameter on efficiency. Two methods, one theoretical and one empirical, were used to predict the optimum forward diameter.

The results show that axial spacing has a negligible effect on efficiency as long as the propellers are operating at their design spacing. The effect of forward propeller diameter on efficiency is shown to be essentially the same as for single propellers. The results further indicate that either of the two methods used to determine the optimum forward diameter is adequate.

Due to limitations imposed by the test equipment the propellers were run at Reynolds numbers lower than usually considered acceptable. The experimental results, however, compare well with theory. From authors' summary

4162. Keyser, R., and Arnoldus, W., Strength calculation of marine propellers, *Inter. Shipbldg. Prog.* **6,** 53, 20–36, Jan. 1959.

Authors deviate slightly from simple beam theory in defining equivalent section moduli of ship propeller sections, use of which yields calculated stresses that agree with experimentally measured stresses. A good survey of the work done in the field is made. Standardized tables and graphs are given for quick determination of hydrodynamic loads, centrifugal loads, section properties of standardized propeller sections, and resulting stresses for these loadings. The material would enable the designer to define light weight, thin blade sections, if only steady loads are considered. As authors point out, little work has been done in designing for vibratory loading.

Authors say variations in lifting forces do not cause equally large variations in blade stresses because of inertia. However, the dynamic response actually depends on how near the exciting frequencies are to the natural frequencies of the blades. At resonance, stress variations will exceed the variations in lifting forces. Authors note that the permissible stresses used for the design of ship propellers are largely based on the long term experience of designers, who have taken the influence of variable loads, the effect of hitting floating objects, and other uncertainties into account. H. Faught, USA

4163. Isay, W.-H., Supplement to the theory of Voith-Schneider propeller (in German), *Ing.-Arch.* **26,** 3, 220–232, 1958.

In previous papers a theory for the flow generated by a Voith-Schneider propeller has been developed both for a free-running propeller and for a propeller in the wake of a ship's hull. In this paper the following supplementary problems are treated: mutual interference of two propellers when abreast, including numerical calculations, propeller moving sideways, refinement of the theory when assuming that the bound vorticity is situated on the contour of the sections instead of on the circumference of the propeller disk. This refinement proves to be important for propellers having a great pitch. H. W. Lerbs, Germany

4164. Vishnyakov, A. V., The calculation of the shearing forces and bending moments due to aerodynamic loads on the wing of a wind motor (in Russian), *Sel'khozmashina* no. 4, 23–26, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9226.

Expressions are derived for the shearing forces and bending moments acting on the wing of a wind motor, determining the form of distribution of the wind loading as found from tests on a number of wind motors. The rectilinear law of distribution of the wind load hitherto used gives exaggerated values to the shearing forces and bending moments. For the bending moment, with a rectilinear law of distribution of the wind loading, the exaggeration is of the order of 50–80% for the outer half of the wing; and 15–20% for the inner half. I. S. Simonov

Courtesy Referativnyi Zhurnal, USSR

Flow and Flight Test Techniques and Measurements

(See also Rev. 3926, 4108, 4111, 4139, 4203, 4224, 4227, 4231, 4248, 4260, 4266, 4295, 4296, 4300, 4333, 4339)

4165. Senshina, K. A., The measurement of pulsating flow velocities by Pitot-Prandtl tubes (in Russian), *Gidrotekh. Stroit.* no. 12, 38–39, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10200.

Author describes a simple fitting for a U-tube manometer enabling continuous recording of the displacement of the meniscus in the legs of the U-tube when measuring pressures in pulsating flows. The fitting consists of two holders, fitted on either side of the manometer panel, and rotated by a motor drive. Having loaded the feeding holder, e.g., with graph paper on paper tape, the operator can trace a curve $h_1(t)$ of the displacements of the meniscus in one leg of the manometer tube, holding a pencil always on the level of the meniscus while winding the paper strip on to the receiving holder. From this curve, the true mean value h for a selected time interval T can be evaluated by graphical integration, which will obviously not be equal to the half-sum of the maximum and minimum values of the position of the meniscus during the time interval T, which is often taken as the mean value. If the two legs of the manometer are precisely identical tubes, the curve of $h_1(t)$ obtained will be the mirror image of the curve $h_2(t)$ obtained for the other leg of the manometer, referred to the mean line between the positions of the meniscuses in the legs; and, if the latter is at zero, obviously, $h_2 = h_1$; from which, for instance, the flow velocity can be calculated, if the pressures have been recorded by a Prandtl tube. As will be remembered, values obtained in this manner do not represent the true pressures in the flow at the orifice of the Prandtl tube in view of the amplitude distortion and phase shift depending on the change in the amplitudes and frequencies due to friction and inertia of the liquid in the measuring apparatus itself.

S. G. Popov

Courtesy Referativnyi Zhurnal, USSR

4166. Kell, C., Free-flight experiments on the measurement of free-stream static pressure at transonic speeds with particular reference to the Mk. 9 pitot-static head, Aero. Res. Counc. Lond. Curr. Pap. 475, 20 pp., 1960.

This note deals with the problem of measuring ambient static pressure at Mach numbers between 0.8 and 1.4; it is in two parts, the first dealing with free-flight measurements of the pressures ahead of bodies of revolution with noses of various shapes. The results indicate the minimum distances ahead of blunt-nosed bodies at which the errors in static pressure measurements are small enough to be acceptable.

The second part of the note deals with errors introduced by the static pressure measuring heads themselves; tests on the standard Mk 9 pitot-static head are described and the results from this and other types of head are presented.

From author's summary

4167. Gutorsky, E. V., A particular case of measurement of the static pressure in a steady flow by electrical means (in Russian), *Trudi Leningrad Politekhn. In-ta* no. 187, 36–43, 1965; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9028.

A brief description of the construction and experimental investigation of a probe intended for measuring the static pressures in a water flow. A compact, induction pressure gage is fitted, either in a separate chamber or directly in the receiving part of the probe. The probe can be rapidly moved in the flow, along a predetermined path, in such manner that the plane of its disk always remains directed approximately parallel to the flow velocity at any point on its path. The probe with the pressure gage fitted directly in the disk is free from inertia forces, but, since there is only one magnet system in the measuring bridge, it is not temperature compensated. The presence of a column of water in the receiving part of the probe, in front of the pressure-gage membrane, makes the instrument subject to inertia, and, at higher velocities, increases the measuring error. It is pointed out that by means of this probe with an induction pressure gage the hydraulic machinery laboratory of the Leningrad Polytechnic Institute has made measurements of the static pressure field in a steady flow. N. A. Preobrazhewskii

Courtesy Referativnyi Zhurnal, USSR

4168. Aleskovsky, A. M., Soloviev, In. V., and Andrushkevich, V. S., A magnetically-compensated pressure gage (in Russian), *Pribory i Tekhn. Eksperiments* no. 1, 110–112, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9031.

A description of a new method of measuring infinitesimal pressures from 10^{-2} to 100 mm Hg, founded on the automatic stabilization of the position of an element subjected to deformation by the action of a pressure gradient. Diagrams of the construction of the pressure gage, and the results of five test series with the experimental prototype, are reproduced. The instrument is practically inertialess, has a linear recording characteristic, and enables measurements to be made with an accuracy within a few per cent.

Yu. G. Zakharov

Courtesy Referativnyi Zhurnal, USSR

4169. Heyser, A., A fast response electronic multimanometer (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957 45–52.

An electronic multimanometer has been developed for the supersonic blow-down wind tunnel at Aachen, using as a transducer an adaptable differential pressure gage of inductance-type for a pressure level from vacuum to 50 atm. Differential pressure gages have been produced for maximum differential pressures from 0.1 to 30 atm, with a range of 1 : 3000. In ring modulator circuits the measured values are rectified and fed to high-speed light spot galvanometers. The measurements can be photographically recorded every quarter of a second to half a second by automatic means. Twelve test channels have been combined into one unit.

From author's summary

4170. Ritchie, V. S., Several methods for aerodynamic reduction of static-pressure sensing errors for aircraft at subsonic, near-sonic, and low supersonic speeds, NASA Rep. 18, 58 pp., June 1959.

Tests were conducted in transonic wind tunnels to investigate and verify experimentally methods for aerodynamically reducing errors due to sensor position, bow-wave passage, and angle of attack. The results indicate that aerodynamic devices of simple design may be employed to reduce errors in sensing static pressures to less than 0.5% at Mach numbers from about 0.40 to 1.15.

From author's summary

4171. Tokar', N. G., and Mokeev, I. I., On the problem of reproduction and measurement of variable forces, *Measurement Techniques* no. 3, 317–319, Nov. 1959. (Translation of *Izmeritel'naia Tekhnika, USSR* no. 3, 55–57, May/June 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

4172. Anissimov, V. A., The problem of flow measurement by thin-walled, submerged weirs (in Russian), *Trudi Vses. N-i. In-ta Gidrotekhn. i Melior.* **29,** 111–116, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10216.

Formulas are presented for determining the flow volume over a submerged weir with a thin wall and without lateral constriction. According to the suggested formulas, instead of measuring the degree of submergence on the side of the tail-race, and the height of the weir, it is proposed to measure the thickness (depth) of the overflow on the edge of the weir. T. N. Astaficheva

Courtesy Referativnyi Zhurnal, USSR

4173. Grey, J., Calibration of turbine flowmeters for cryogenic operation, *ARS J.* **30,** 2, 192–193 (Tech. Notes), Feb. 1960.

4174. Naumann, A., Heyser, A., and Trommsdorff, W., The high pressure wind tunnel in Aachen (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 33–45.

Paper gives a brief description of the first stage of installation of the supersonic blow-down wind tunnel at Aachen, which was running for the first time in October 1955. After a general presentation of the aerodynamic performance, giving essentially the effect of the working conditions of the tunnel on the constancy of the Reynolds number, the valve and the heat accumulator are described.

The tunnel works intermittently, the normal running time is 20 to 30 sec at maximum; the test jet of the vertical test chamber (22-cm diameter) leaves the axisymmetrical Laval nozzle as a free jet at ambient pressure and temperature.

Based on a pneumatic principle, the valve operates as a quick-opening valve as well as pressure control device. The air is heated in a heat accumulator containing about 7.5 tons of storage material (iron sheets); the storage material can be heated by means of a gas apparatus to a temperature of 560 C at maximum.

The constancy of stagnation pressure achieved is within ±1%.

From authors' summary

4175. Barshtein, M. F., The dynamic analysis of a high cylindrical structure (in Russian), Researches on the dynamics of structures, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 1957, 6-43; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9796.

Results are presented of experimental investigations conducted in the wind tunnel of the TsAGI on the oscillations of a rigid cylinder on an elastic support and an elastic cylinder in an air flow. It was found that oscillations of the cylinder take place principally in a direction perpendicular to the air flow and have a frequency

close to the natural oscillation. A theory is constructed based on the phenomenon shown, on the assumption that in or near the end positions of the cylinder, as a result of vortex shedding, discontinuous variation of the circulation takes place while in all intermediate positions the circulation remains unchanged. When solving the problem of the oscillation of elastic cylinders, it is also assumed that its elastic curve coincides with the form of the fundamental oscillation. From the solution of the nonlinear equations of motion, the frequency of oscillation is determined, which, on first appearance, is found to coincide with the frequency and amplitude of the natural oscillations. Recommendations are made also in regard to the dynamic analysis for high buildings of cylindrical shape, using empirical coefficients, obtained from the experiments made. M. D. Klyachko

Courtesy Referativnyi Zhurnal, USSR

4176. Laberge, J. G., Half-model measurements of longitudinal force and moment characteristics of AGARD model 'B' at subsonic and supersonic speeds, Nat. Res. Counc., Canada LR 267, 25 pp., Dec. 1959.

This report presents longitudinal force and moment characteristics of AGARD model 'B' as measured on a half model in the N.A.E. 30-inch × 16-inch high-speed wind tunnel over a Mach number range from 0.375 to 2.03. From author's summary

4177. Gillis, C. L., and Vitale, A. J., Wing-on and wing-off longitudinal characteristics of an airplane configuration having a thin unswept wing of aspect ratio 3, as obtained from rocket-propelled models at Mach numbers from 0.8 to 1.4, NASA TN D-7, 42 pp., Mar. 1960.

Flight tests were conducted on three rocket-propelled models of an airplane configuration, two models having thin unswept wings of aspect ratio 3 and hexagonal airfoil sections, and the third having no wing. The two winged models had wings of different stiffness characteristics. Aerodynamic derivatives defining the static and dynamic longitudinal stability, control, trim, and drag characteristics of the configuration were obtained over a Mach number range from 0.8 to 1.4. For some of the aerodynamic derivatives the separate effects of the wing, tail, and fuselage were determined. From authors' summary

4178. Lockwood, V. E., and McKinney, L. W., Lift and drag characteristics at subsonic speeds and at a Mach number of 1.9 of a lifting circular cylinder with a fineness ratio of 10, NASA TN D-170, 21 pp., Dec. 1959.

An exploratory wind-tunnel investigation has been made on a circular cylinder at subsonic speeds and at a Mach number M of 1.9 to determine the feasibility of using small flaps to develop lift for possible reentry application. Several full-span flaps attached normal to the lower surface of the cylinder and varying in chord from 0.004 to 0.300 diameter were used as lift-generating devices. Most of the tests were made with flaps located at the 50-percent-chord station, although a few tests were made with the chordwise location as one of the parameters. The investigation was made on a cylinder with a fineness ratio of 10 over a Mach number range from 0.07 to 0.08 and at $M = 1.9$. The investigation covered a range of Reynolds number from 355,000 to 1,600,000.

The results indicated that lift could be generated throughout the range of Mach numbers of the investigation. For flaps located at the 50-percent-chord station, increases of flap size up to 20% of the cylinder diameter gave increases of lift coefficient, a maximum of 1.63 being obtained at a Mach number of 0.3. The lift effectiveness of all flaps decreased rapidly above a Mach number of about 0.3 but was positive for all Mach numbers of the investigation when the flap chord was 5% or greater. The ineffectiveness of small flaps could be slightly improved at higher subsonic Mach numbers by locating them near the leading edge. The drag of a lifting circular cylinder increases rapidly at subcritical Mach numbers as the flap chord is increased, but at a Mach number of 1.9 the drag of the cylinder with the 10-percent-chord flap was only about 7% higher than that of the nonlifting cylinder. For Mach numbers up to 0.5 the lift-drag ratios of the cylinder with flaps attached at the 50-percent-chord station were relatively independent of flap size for values between 5 and 20% of the chord. For a flap chord of 10 the lift-drag ratio decreases from a high of about 2.2 at a Mach number of 0.3 to a low of about 0.2 at a Mach number of 1.9.

From authors' summary

4179. Julius, J. D., Measurements of pressure and local heat transfer on a 20° cone at angles of attack up to 20° for a Mach number of 4.95, NASA TN D-179, 28 pp., Dec. 1959.

The distribution of pressure and local heat transfer on a 20° included-angle cone at a Mach number of 4.95 and at angles of attack up to 20° were measured. Data were obtained in a Reynolds number range of 14×10^6 to 75×10^6 per foot based on free-stream conditions.

The measured pressures were compared with the first-order and second-order approximations of exact cone theory and with Newtonian and modified Newtonian theory. The data were best predicted by Newtonian theory.

The heat-transfer rates along the most windward generator of the cone increased with increasing angle of attack. The theories of NACA Technical Notes 4152, 4380, and 4208 were compared with the present data. They provided reasonable predictions of the experimental data when the pressure was determined to the second order (Tech. Rep. No. 5, M.I.T.cone tables) and other local conditions were determined to the first order (Tech. Rep. No. 3, M.I.T., cone tables). Heat transfer was greatest along the most windward generator, $\phi = 0°$, when the flow was wholly laminar. When transition was observed, the $\phi = 30°$ generator generally showed the highest heat transfer.

From author's summary

4180. Johnston, P. J., and Witcofski, R. D., Effect of a variable-geometry diffuser on the operating characteristics of a helium tunnel designed for a Mach number in excess of 20, NASA TN D-237, 20 pp., Feb. 1960.

An experimental investigation has been conducted in a 3-inch helium tunnel equipped with a conical nozzle and operating at a Mach number of 20 to determine the effectiveness of variable-geometry supersonic diffusers in decreasing the pressure ratio required to maintain flow. Four diffuser entrance wall lengths were investigated. The results indicate that the over-all pressure ratio required to maintain flow could be decreased 34% from that required at an area ratio of unity by utilizing an optimum combination of diffuser entrance wall length and diffuser entrance wall angle. For this combination, only 61% of test-section pitot pressure could be recovered by this diffuser.

From authors' summary

4181. Warren, W. R., Determination of air stagnation properties in a high-enthalpy test facility, *J. Aero/Space Sci.* **26,** 12, 835–836 (Readers' Forum), Dec. 1959.

4182. Wecker, M. S., On the use of a spark-driven shock tube to prepare nonequilibrium gas samples, *J. Aero/Space Sci.* **26,** 12, 848–850 (Readers' Forum), Dec. 1959.

In a spark-driven shock tube, the driver and driven gas are at the same pressure (no diaphragm) before the discharge occurs in the driver. After discharge a shock propagates in the usual manner and reflects from the tube end. The chemical reaction occurs in the reflection region, where the gas is first heated by the reflected shock and then rapidly cooled by an expansion wave which is produced when the reflected shock passes through the contact surface. Paper is a brief summary, with little detail, of the original work (M. Aero. E., Cornell U., 1959). A. Roshko, USA

4183. Becker, E., Boundary layer effects in the tube wind tunnel (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 232–237.

The tube wind tunnel [AMR 9 (1956), Rev. 860] is a new type of intermittent-flow blow-down tunnel with air supply stored in a long tubular vessel. For a certain time interval a flow of constant stagnation pressure and temperature is maintained in the De Laval nozzle. Unfortunately the ideal behavior cannot be obtained by the influence of the boundary layer. The development of the unsteady laminar and turbulent boundary layer is investigated using the Kármán-Pohlhausen approximation. The effect of heat transfer is taken into account but compressibility is neglected.

The results are used to calculate the deviation of the stagnation pressure, which is of the order of 2–3% in the initial period (as long as fully developed tube flow is not reached). Experiments with a small tube wind tunnel of 16-m length and 30-mm inner diameter confirm the theoretical predictions. In order to avoid the discussed deviations it is proposed to construct the tube wind tunnel in a slightly conical form.

W. Wuest, Germany

4184. Naumann, A., Problems and results of applied research in gas dynamics (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 24–33.

A brief description of the new supersonic blow-down wind tunnel at Aachen is given and followed by some remarks on the starting process of the supersonic flow in a system of Laval nozzle and diffuser.

Two arrangements for accelerating the start of supersonic wind tunnels are discussed. In order to make possible the development of the flow at low initial pressure, the use of an ejector, operating over a short period of time, is suggested for accelerating downstream the shock wave which is blocked in the nozzle. A large diffuser cross-section area, necessary for swallowing the shock wave, is provided for the starting period by opening a channel which by-passes the diffuser throat. The experiments relating to these two suggestions are described.

Finally the flow pattern of a cylinder beyond the critical Mach number is discussed. The alternating rolling up of the surface of discontinuity exists here in a fashion similar to that to the formation of the Kármán vortex street. The interference between the separation of the boundary layer and the formation and the oscillation of a shock wave is explained with reference to the additional circulation associated with the formation of vortices. The surface of discontinuity being responsible for downstream flow, an alternating formation of vortices must be expected also to occur in the case of turbulent separation of the boundary layer at high supercritical Mach numbers.

The flow patterns are illustrated by schlieren photos and by films. From author's summary

4185. Burns, Anne, Fatigue loadings in flight: loads in the tailplane and fin of a jet Provost, Aero. Res. Counc. Lond. Curr. Pap. 440, 36 pp., 1959.

Instrumentation details are given with measured flight stresses on tailplane (stabliizer) and vertical fin of an RAF jet trainer.

W. H. Sparing, USA

4186. Sheppard, L. M., Some free flight tests on the sonic area rule and wing-body wave drag, Austral. Defence Scient. Service, Weapons Research Establishment TN HSA 51, 29 pp., June 1959.

Results are presented for a program of free flight tests relating to the transonic area rule. These tests investigated the zero-lift wave drag of wings and equivalent bodies, having the same cross-sectional area distributions, and also the effect on wave drag of the body cross-sectional shape.

When the wing has a round-nosed RAE 104 section it has a higher transonic drag-rise than its equivalent body; this suggests that a leading edge drag force varying with free-stream Mach number does exist. Insofar as body cross-sectional shape is concerned the results show that it does not influence the sonic drag-rise of a thin wing and slender body combination.

From author's summary

4187. Rumsey, C. B., Piland, R. O., and Hopko, R. N., Aerodynamic-heating data obtained from free-flight tests between Mach numbers of 1 and 5, NASA TN D-216, 21 pp., Jan. 1960.

Two rocket-propelled models have been flown to Mach numbers of 5.0 and 5.6. Aerodynamic-heating data were obtained from temperature measurements made at a single station on each model. In the case of model 1, data were obtained on the parabolic nose between free-stream Mach numbers of 2.3 and 5.0. The local Mach number, which is the Mach number of the airstream just outside the boundary layer at the measuring station, varied from 2.1 and 4.5; these values corresponded to local Reynolds numbers of 11×10^6 to 19×10^6. The ratio of skin temperature to local static temperature varied from 1.1 to 2.6. The experimental data when reduced to Stanton numbers were in fair agreement with values predicted by Van Driest's theory for heat transfer on a cone with turbulent flow from the nose tip.

Aerodynamic-heating data were obtained on the conical nose of model 2 between Mach numbers 1.1 and 4.0. The local Mach numbers varied from 1.0 to 3.8; these values corresponded to local Reynolds numbers from 14×10^6 to 28×10^6. The ratio of skin temperature to local static temperature varied from 1.0 to 2.3. Over most of the test range, the data were in fair agreement with Van Driest's theory for turbulent flow on a cone.

From authors' summary

4188. Stallabrass, J. R., Flight tests of an experimental helicopter rotor blade electrical de-icer, Nat. Res. Counc., Canada LR 263, 52 pp., Nov. 1959.

A sprayed metal in resin rotor blade de-icing mat employing the spanwise shedding principle was tested on a helicopter in flight under simulated icing conditions. The results showed that, despite shortcomings in the design of the heater elements used, this method of de-icing is practical and can result in clean, efficient shedding of ice. In particular, the negligible increase in vibration resulting from asymmetric shedding makes the spanwise shedding method attractive for small helicopters having limited electrical generating capacity. From author's summary

Thermodynamics

(See also Revs. 3823, 3826, 3827, 3987, 3989, 4068, 4077, 4078, 4173, 4213, 4242, 4280, 4282)

Book—4189. Hougen, O. A., Watson, K. M., and Ragatz, R. A., Chemical process principles, Part 2, Thermodynamics, 2nd ed., New York, John Wiley & Sons, Inc., 1959, lvi + 505–1072. $9.75.

The chemical engineer is frequently faced with the problem of determining the properties of a system, or its behavior on being subjected to certain external influences, when insufficient data are available for an exact calculation. The present text is designed to train the student to solve these problems insofar as thermodynamics can be of help. This volume is a considerable enlargement of the earlier edition.

After a rather brief introduction to the three laws of thermodynamics, the properties of pure fluids are discussed and presented in reduced form in extensive tables and a number of charts. Chapters on expansion and compression of fluids and on the thermodynamics of fluid flow are followed by three chapters on power and refrigeration cycles. There are chapters on gaseous and nonelec-

trolyte condensed solutions, on liquid-vapor equilbria at low and at high pressure, on solubility and adsorption, and on separation processes. The last three chapters are on chemical equilibria and contain a short section on voltaic cells. The author and subject indices cover Volumes I and II.

There are many tables of data. The more than 140 figures and charts are well drawn and informative. The discussion of each major topic is followed by an illustrative numerical problem worked out in detail, and there are 91 problems for the student to work.

The emphasis is on the solution of process problems, and in this respect the choice of topics is excellent and the treatment of each is, in general, full. The discussion of the fundamentals of thermodynamics is not only quite brief, but is not as well done as the presentation of the applications. There should be some mention of solution of electrolytes and this would permit a more extended treatment of voltaic cells. J. A. Beattie, USA

4190. Kriese, S., Precision of the computation of a thermodynamic cycle (in German), *Brennstoff-Wärme-Kraft* **11,** 7, 307–312, July 1959.

The author points out that the tabular entries in steam tables are estimates of the state quantities of the water-steam system. Accordingly they are subject to uncertainties for which estimates have been made. These uncertainties give rise to corresponding uncertainties in the results of heat balance and cycle calculations. Therefore, estimates of heat rate may be uncertain to the extent indicated by probable errors of the order of 0.3%.

M. A. Mayers, USA

4191. Kobe, K. A., and Murti, P. S., Ideal critical volume for generalized correlations—application to the Macleod equation of state, *Indust. Engng. Chem.* **51,** 3, p. 332, Mar. 1959.

4192. Hersh, C. K., Brabets, R. I., Platz, G. M., Swehla, R. J., and Kirsh, D. P., Vapor-liquid equilibria of ozone-oxygen systems, *ARS J.* **30,** 3, 264–266 (Tech. Notes), Mar. 1960.

4193. Callendar, G. S., and Egerton, A., An experimental study of the enthalpy of steam, *Phil. Trans. Roy. Soc. Lond.* **252,** 1006, 133–164, Jan. 1960.

The measurements on the total heat of steam by the condenser method carried out between the years 1931 and 1940 are described. The apparatus was adapted from that used for the measurement of the saturation pressure of steam [Egerton & Callendar, 1932]. Part I deals with the investigation of the sources of error, particularly the heat-loss correction, as a result of which the modifications in the apparatus described in part II were made. The final measurements, amounting to about 400, range from 10 to 225 Kg/cm² and from 200 to 600 °C, at intervals of about 25 Kg/cm² and 25 °C. The smoothed results are also given in bars, and are considered to lie within about 1 part in 1500 of the true values.

From authors' summary

4194. Bousso, E., The viscosity of air at high rates of shear, *Bull. Res. Council Israel* **7C,** 3, 136–139, Dec. 1959.

An instrument for the measurement of the viscosity of air at high rates of shear is described together with the reasons for the design chosen. The values obtained for the viscosity were lower than those measured by other methods. An explanation is offered on the basis of slippage of gas molecules adjacent to the surfaces.

From author's summary

4195. Snider, R. F., and Curtiss, C. F., Kinetic theory of moderately dense gases, *Physics of Fluids* **1,** 2, 122–138, Mar.–Apr. 1958.

Authors study effect of collisional transfer on transport coefficients of gas composed of nonrigid molecules, neglecting effect of multiple collisions. First-order density correction to thermal conductivity and viscosity is obtained by perturbation of Boltzmann equation. C. E. Pearson, USA

4196. Gerasimov, A. N., On the stationary distribution of mutually attracting particles, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 2, 592–596, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Author considers an infinite number of particles which are only subjected to the force of mutual attraction in accordance with Newton's law. With the assumption of a stationary state (in the thermal sense) such a model becomes spherically symmetric about the center of mass. Author then derives a nonlinear integral equation relating pressure to density. He calls pressure the force of mutual attraction per unit area. By assuming any arbitrary equation of state and prescribing the temperature distribution, the resultant density distribution can be calculated and vice versa. Author then uses the equation of state $p(r) = (k/m)\,\rho(r)\,T(r)$. It appears to this reviewer that this is the ordinary equation of state; however, author calls it the Clapeyron equation, which is known to the reviewer as a relationship between temperature and log of pressure. In any case the above state equation is used and yields an ordinary differential equation relating temperature and density. Several examples are carried out and for the isothermal case the barometric relationship, $\rho = \rho_0 \exp(-m\,g\,h/k\,T)$, is obtained. Reviewer has some doubts as to the validity of the derivations carried out in this paper.

F. L. Schuyler, USA

4197. Wilson, G. W., and Lindley, B. C., Thermoelectric power—An investigation of its possibilities, Parts 1, 2, and 3: Present methods of power generation; Design and performance; General discussion, *Engineering* **188,** 4871, 97–99, Aug. 1959; **188,** 4872, 129–132, Sept. 1959; **188,** 4873, 161–162, Sept. 1959.

An extensive presentation of thermoelectric power, prepared in three parts.

Part one contains a detailed explanation of thermoelectric and thermionic devices together with the theoretical principles involved. Special concepts such as efficiency of generation and the figure of merit are given in considerable detail. Interesting tables and graphs are used to enlarge the subject. The second part consists of discussions covering engineering design parameters and the proposed generating systems. Data are presented in many diagrams to amplify the text material. Consideration is given to the coupling of the techniques for power generation under discussion to nuclear power sources. The third part covers an approximate economic analysis of thermoelectric and thermionic systems for the generation of electric energy. Further improvements in materials and methods of construction may lead to performance of systems which will be equivalent in thermal efficiency to existing generating systems.

The paper is recommended for those interested in a proposed new method for electric power generation.

G. A. Hawkins, USA

4198. Airapetiants, C. V., Thermal electromotive force and additional thermal conductivity of statistical mixtures, *Soviet Phys.–Tech. Phys.* **2,** 3, 429–433, Mar. 1957 (Translation of *Zh. Tekh. Fiz., USSR* **27,** 3, 478–484, Mar. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.)

According to Ioffe [Acad. Sci., USSR Press, 1950 and 1956], the thermoelectric efficiency of a generator or the cooling coefficient of a thermoelectric refrigerator can be determined by the operating temperature and the parameter $Z = \alpha^2\sigma/K$ which depends on the properties of the semi-conductor used. Here α is the thermoelectric power; and σ/K is the ratio of electric to thermal conductivities. The maximum Z occurs at $\alpha \simeq 200\ \mu v/\text{deg}$. The optimal value of α is attained by appropriate addition of impurities to regularize the number of current carriers. To reduce the thermal

conductivity it is useful to utilize pseudo binary systems of solid solutions. In this case, however, if the substance is prepared by alloying the basic components, segregation takes place as it crystallizes. This results in an inhomogeneity of impurities so that various parts of the ingot have different values of α, σ and K. Hence thermoelements prepared by compression of powders of this alloy will have inhomogeneous properties. The formation of such tablets represent a statistical mixing of particles of varying values of α, σ and K. Values of σ and K can be evaluated by existing methods [Odelevskii, *J. Tech. Physics (USSR)* **21**, p. 678, 1951]. This article presents a method for evaluating α for such statistical mixtures. S. Lampert, USA

Book—4199. Plank, R., edited by, Handbook of refrigeration, Vol. VII, Absorption refrigeration engines [Handbuch der Kältetechnik, Siebenter Band, Sorptions-Kältemaschinen], Berlin, Springer-Verlag, 1959, xviii + 540 pp. + 5 diagrams. DM 76.80.

This is the most extensive work on the subject the reviewer knows with the possible exception of collections of *unpublished* studies made by companies manufacturing sorption refrigeration systems.

Material is presented simply and is well arranged. However, in reviewer's opinion, it is a thorough presentation of the fundamentals of sorption refrigeration rather than a typical engineering handbook. It should constitute excellent background reading for engineers interested in the refrigeration field and also should be of great help in clarifying some of the problems confronting a specialist.

The extensive bibliography provides excellent sources for further study of any particular problem.

As a handbook, it should be used in conjunction with other volumes.

The material is presented in three sections:

(1) Fundamentals of the theory, describing periodical and continuous sorption cycles; Carnot and Lorenz cycles; theoretical cycles for one-stage and multi-stage systems; thermodynamic calculations of ideal and practical cycles; heat losses during different processes of the cycle and expected thermal efficiencies. Numerous examples are presented and the cycles are illustrated in $\log p$ versus $1/T$ diagram. The use of Merkel-Bosnjakovic $i - \zeta$ diagram for ammonium-water solution for calculation of refrigeration cycles is described. A large-size diagram is included with the book. Advantages and disadvantages of different fluids used in present sorption refrigeration systems are discussed.

(2) Small-size sorption refrigerators. It discusses old and new systems of periodic and continuous sorption systems with liquid and solid sorption mediums; present construction of components of the systems; thermal calculation and thermal efficiencies or processes; economical considerations and comparison with compression refrigeration.

(3) Large-size sorption refrigeration systems. It presents design and available types of gas-, steam-, hot-fluid-heated boilers, rectification columns, condensers, evaporators, absorbers, pumps; numerous schemes and photographs of systems built by different companies; maintenance, adjustment and starting procedures of sorption systems; application and economical consideration in chemical industry and gas purification, milk and chocolate industries, beer producing, air conditioning and water cooling; refrigeration systems by Servel, Inc., and Carrier Corporation.

I. A. Black, USA

4200. Mattarolo, L., Flow in capillary tubes of refrigerating equipment (in Italian), *Termotecnica* **13**, 11, 531–539, Nov. 1959.

4201. Mattarolo, L., Refrigeration cycle with a capillary tube (in Italian), *Termotecnica* **13**, 11, 540–546, Nov. 1959.

4202. Refrigerating data sheets in the MKSA-unit system (in English), *Kyltekn. Tidskr.* **18**, 4, 44 pp., Aug. 1959.

4203. Clark, D. D., An assessment of the probable causes of variation of the speed-correction coefficient of aircraft thermometers, Aero. Res. Counc. Lond. Rep. Mem. 3127, 17 pp., 1959.

Authors have attempted to list all factors which could possibly affect the speed correction coefficient in order to assess the importance of each. The two most important factors are variations in heat exchange in the thermometer pitot head and transition from laminar to turbulent boundary layer. Both factors decrease the coefficient with altitude and increase the coefficient with speed. Two factors having negligible effect are variation in specific heat of air and variation in Prandtl number.

R. J. Mindak, USA

4204. Gordov, A. N., and Ergardt, N. N., Some causes of errors in the measurement of temperatures by means of thermocouples, *Indust. Lab.* **24**, 12,1605–1607, Dec. 1958. (Translation of *Zavod. Lab., USSR* **24**, 12, 1467–1469, Feb. 1960 by Instrument Society of America, Pittsburgh 22, Pa.)

4205. Danishevskii, S. K., The immersion of thermocouples, *Indust. Lab.* **24**, 12, 1608–1613, Dec. 1958. (Translation of *Zavod. Lab., USSR* **24**, 12, 1470–1474, Feb. 1960 by Instrument Society of America, Pittsburgh 22, Pa.)

4206. Haupin, W. E., Hot wire method for rapid determination of thermal conductivity, *Bull. Amer. Ceram. Soc.* **39**, 3, 139–141, Mar. 1960.

Thermal conductivity can be determined with engineering accuracy by inserting into the specimen a line heat source consisting of a butt-welded thermocouple heated by alternating current. Thermal conductivity is calculated from the rate of temperature rise of the thermocouple. An electrical network is described which permits the reading of a fraction of a millivolt thermal emf in the presence of several volts of alternating current. The method has the advantage of being fast and simple to run, and it does not require complicated equipment. From author's summary

4207. Vines, R. G., Measurement of the thermal conductivities of gases at high temperatures, *ASME Trans.* **82**C (*J. Heat Transfer*), 1, 48–52, Feb. 1960.

Experimental results are reported for the thermal conductivities of air, argon, nitrogen, and carbon dioxide at temperatures up to 900 C, and of steam up to 560 C. These results are compared with values predicted from correlation formulas based on low temperature measurements. From author's summary

4208. Schaefer, C. A., and Thodos, G., Thermal conductivity of diatomic gases: liquid and gaseous states, *AIChE J.* **5**, 3, 367–372, Sept. 1959.

After an extensive literature survey the experimental thermal-conductivity data for twelve diatomic gases were utilized to produce an accurate and expedient means of predicting values over extensive ranges of temperature and pressure. Plotting values of k^* against T_R on logarithmic coordinates produced similarities pointing to the existence of corresponding states behavior for this family of substances with the exception of hydrogen. Because hydrogen cannot be included in a correlation generalized for the diatomic gases, it has been eliminated from this study. Based on atmospheric pressure data, ratios of $k^*/k^*_{T_c}$ produced a unique relationship with reduced temperature. To include the effect of pressure, residual thermal conductivities were correlated with density for nitrogen and oxygen, the only substances for which high-pressure data exist. These relationships enabled the determination of the thermal conductivity at the critical point. When the value $k_c = 8.55 \times 10^{-5}$ cal./sec cm °K for nitrogen was used, an extensive reduced thermal-conductivity correlation was constructed against reduced temperature for parameters of constant reduced pressure. This chart, extending to reduced pressures of

100 and to reduced temperatures of 85, is recommended for the diatomic gases in their gaseous and liquid states.

The developed correlation reproduces experimental nitrogen data to within 1.39%. For the other diatomic gases experimental agreement extends from 1.00 to 3.2%. Such agreement indicates that this correlation is more reliable for the diatomic gases than are other generalized plots presented in the literature.

From authors' summary

Heat and Mass Transfer

(See also Revs. 3776, 3823, 3839, 3841, 3842, 3951, 4067, 4071, 4074, 4089, 4106, 4108, 4179, 4187, 4198, 4199, 4260, 4261, 4262, 4263, 4268, 4277, 4282, 4333)

4209. Frenkel, V. Ya., Concerning the calculation of the thermal mode of operation of the grid block of a radio tube, *Soviet Phys.-Tecb. Phys.* **4**, 6, 696–700, Dec. 1959 (Translation of *Zb. Tekb. Fiz., USSR* **29**, 6, 773–778, June 1959 by Amer. Inst. Phys., New York, N. Y.

The temperature distribution in the grid of a vacuum tube is investigated. The grid consists of wires placed between cross members which in turn are supported by insulators. The array is subject to a fixed heat input from the electron stream and it loses heat by radiation, while conduction tends to equalize the temperature of the array.

The analysis is not particularly profound but the problem is interesting. It is stated that it is important in vacuum tube design since thermal emission from the grid and sagging of grid wires must be avoided.

W. Squire, USA

4210. Ness, A. J., Solution of equations of a thermal network on a digital computer, *J. Solar Energy Sci. Engng.* **3**, 2, p. 37, Apr. 1959.

The Newton-Raphson iterative method of solving a system of nonlinear algebraic equations, which represent the energy balances at various nodes of a thermal network, is suggested. The application of the method to a specific problem, the limitation of the computer memory capacity and the time required to solve a system of 15 equations on an IBM-650 digital computer are briefly discussed.

R. Viskanta, USA

4211. Jeckel, H., Method of calculating quasi-steady temperature distributions in solid bodies with controlled boundary conditions (in German), *ZAMP* **10**, 2, 133–142, Mar. 1959.

Author investigates a heat-conduction problem in a three-dimensional body K with the surface F,

$$\frac{\partial T}{\partial t} - a^2 \Delta T = 0 \text{ in } K, \qquad [1]$$

$$T(P, 0) = f(P), \qquad [2]$$

$$\left(\frac{\lambda}{\alpha}\frac{\partial T}{\partial n} + T\right)_F = \phi\ (P, t). \qquad [3]$$

Here P is the point of K, in [3] of the surface F, $T(P, t)$ is the temperature, $f(P)$ the initial temperature, $\phi\ (P, t)$ prescribed "Steuerfunktion" on F, Δ the Laplacian operator, $\frac{\partial T}{\partial n}$ derivative in the outside-normal direction, a^2, λ, α constants.

If a so-called quasistationary solution of the problem (e.g. for great values of t) is to be found, one may choose two different ways:

The first one lies in neglecting the initial temperature [2], so that one solves only problem [1], [3].

The more general method is investigated by the author: Solution of [1], [2], [3] may be written by use of Green's function (more precisely using eigenfunctions of a certain problem) in an explicit form. Analyzing this form of the solution, author may affirm that under some suppositions about $\phi\ (P, t)$, the quasistationary solution of the investigated problem exists and may be constructed, following a method, presented in detail by the author.

Author presents then, as example, the solution of a problem, solved previously by V. Vodička, and gets Vodička's result as a special case of his method.

K. Rektorys, Czechoslovakia

4212. El-Darwish, A. S., Aperiodic comparative measurement of heat conductivity of metals (in German), ETH, Zurich Promotionsarbeit 2800, 41 pp., 1958.

Author developed method of measuring thermal conductivity λ of solid metals by an unsteady method which is based on known solution of temperature history of a semi-infinite solid, initially at uniform temperature, whose surface is brought instantaneously to another temperature. If two such solids, initially at different but uniform temperatures T_1 and T_2, are brought into contact, the interface temperature assumes a fixed value T_0, such that

$$\frac{T_1 - T_0}{T_0 - T_2} = \sqrt{\frac{\lambda 2 c 2 \gamma 2}{\lambda 1 c 1 \gamma 1}}$$

(c = specific heat, γ specific gravity). If $\sqrt{\lambda_1 c_1 \gamma_1}$ is known for one of the solids, λ_2 can be found if c_2 and γ_2 for the other one are found by independent methods.

In applying this theory to actual measurements with cylindrical specimens it was necessary to overcome certain objections. (a) By using a contact fluid the contact resistance was reduced to a small value. (b) Because specimens of finite lengths must be used, the interface temperature T_0 remains constant for a limited period only. Author showed that this fixed value is the same as for two semi-infinite solids, and that the limited period is sufficiently long for completion of all measurements. Author also reduced errors due to finite diameter of specimens to acceptable limit s.

Method requires accurate measurement of the interface temperature T_0. Author gives insufficient details of how this was accomplished. As explained, the thermocouple circuits could not have achieved results which on the face of it seem satisfactory.

Unsteady methods appear to be attractive because they require much less time than steady ones. In fact, author's method requires rather large specimens, and although period required to complete measurements is short, the preliminary heating of the two specimens to uniform temperatures is long and much of the apparent advantage is thus cancelled.

Y. R. Mayhew, England

4213. Platunov, E. S., The "multi-point" method for determining the separate coefficients of heat loss of bodies of simplest form (in Russian), Issledovariya v obl. teplovykh izmereniy i priborov, Leningrad, 1957, 78–82; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8916.

A method is suggested for determining the mean values of the coefficients of heat loss from the lateral surfaces and base of a circular cylinder of finite length as well as on the faces of a rectangular parallelepiped. The method is based on the cooling of a body of corresponding form in a liquid or gaseous medium at constant temperature in regular conditions. By measuring the temperatures at a number of points on the body during cooling it is possible to determine the mean values of the coefficients of heat loss on its faces, if the thermophysical properties of the body are known.

V. S. Petukhov

Courtesy Referativnyi Zhurnal, USSR

4214. Westervelt, P. J., Effect of sound waves on heat transfer, *J. Acoust. Soc. Amer.* **32**, 3, 337–338, Mar. 1960.

The suggestion is put forward that the effect of sound waves on heat transfer is dominantly a result of the modification of the inner streaming boundary layer which is known to occur when the sound particle displacement amplitude s exceeds in magnitude the acoustic boundary-layer thickness δ_{ac}.

From author's summary

4215. Siegel, R., and Sparrow, E. M., Turbulent flow in a circular tube with arbitrary internal heat sources and wall heat transfer, *ASME Trans.* **81** C (*J. Heat Transfer*), 4, 280–290, Nov. 1959.

An analysis has been carried out to determine the heat-transfer characteristics for turbulent flow of a heat-generating fluid in a circular tube with wall heat transfer. The internal heat generation is uniform over the tube cross section, but may vary longitudinally in an arbitrary manner. The wall heat transfer may also vary in an arbitrary way in the longitudinal direction. The analysis applies along the entire length of the tube, that is, in thermal entrance as well as fully developed regions. The fluid is assumed to have a fully developed turbulent velocity profile throughout the length of the pipe. Numerical results are presented for fluids with Prandtl numbers ranging from 0.7 to 100 for Reynolds numbers from 50,000 to 500,000. The extension of the results to include radial heat source variations is indicated.

From authors' summary by F. Krupka, Czechoslovakia

4216. Baines, W. D., On the transfer of heat from a river to an ice sheet, Nat. Res. Counc., Canada MH–93, 16 pp., Oct. 1959.

Thermal conditions in a river channel covered with ice are briefly considered. It is seen that the least information is available on the rate of heat transfer from the water to the ice. A conventional heat-transfer formula is applied and examples are given of its use. It is shown that very small temperature differences must exist between the water and the ice sheet. The effect of the ice sheet on the flow is also considered.

From author's summary

4217. Fowler, J. M., and Warner, C. F., Measurements of the heat transfer coefficients for hydrogen flowing in a heated tube, *ARS J.* **30**, 3, 266–267 (Tech. Notes), Mar. 1960.

4218. Sogin, H. H., Heat transfer from surfaces of nonuniform temperature distribution; Part 1, Laminar transfer from isothermal heat poles on a flat plate, AFOSR TN 58–930 (Brown Univ., Div. Engng; ASTIA AD 205 095), 81 pp., Nov. 1958.

The Rubesin-Klein-Tribus method [NACA TN 2345 and Heat Transfer Symposium, University of Michigan, 1952] was developed to calculate the heat transfer from surfaces with arbitrary temperature distributions. This method is used in the present paper to determine the heat transfer under more extreme conditions, viz. over a flat plate which is adiabatic except for two distinct finite lengths which are heated. The laminar step function derived by Eckert (on pages 88–92 of his book) is used to correct for the unheated hydrodynamic starting length on the plate.

Experimental check of the calculations is made on the basis of the heat-mass transfer analog. Trays of naphthalene separated by inert matter are used as the mass "poles" to simulate the heat "poles" with an adiabatic surface between them.

For laminar flows with velocities of 40 to 90 fps and air temperatures from 72 to 88 F the experimental and theoretical results were in good agreement. Thus the application of the calculation method and Eckert's step function to problems with extreme thermal boundary-condition variations appears to be justified.

S. Ostrach, USA

4219. Kudriashev, L. I., The theory of similarity as a method for the construction of approximate analytical solutions of problems in hydromechanics and heat exchange (in Russian), *Sb. Nauchn. Trudi Kuibyshevsk. Industr. In-ta* no. 6, pt. 1, 157–177, 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8910.

A comparison of the equations of motion and energy for a viscous incompressible fluid furnishes equations linking friction and heat exchange.

$$q_0 = \frac{c_p g (t_f - t_w)\tau_0}{w_0}$$

q_0 = specific heat flow, c_p specific heat, $(t_f - t_w)$ difference in temperature between the flow and the wall, w_0 flow velocity, τ_0 coefficient of friction. The critical relationships determining the coefficients of heat exchange for a plate and a pipe are discussed for the cases of constrained and free motion of the fluid.

V. S. Avdrevskii
Courtesy Referativnyi Zhurnal, USSR

4220. Martin, B. W., Free-convection heat transfer in the inclined open thermosyphon, Instn. Mech. Engrs., Prepr., 17 pp., 1959.

Extension of earlier work [*Proc. Roy. Soc.* (*A*) **230**, p. 502, 1955] to inclined system for experimental study of effects of acceleration normal to tube axis. Conjecture as to increased effectiveness is demonstrated for sufficiently large inclinations after initial decrease in heat transfer for small departures from vertical.

J. R. Baron, USA

4221. Allen, P. H. G., Electric stress and heat transfer, *Brit. J. Appl. Phys.* **10**, 8, 347–351, Aug. 1959.

This work investigated experimentally the influence of electric fields on natural convection heat transfer in electrically nonconducting fluids. The test cell was a 7/8-inch-diameter brass cylinder, closed at both ends, with a 0.001-inch-diameter platinum wire suspended on the tube centerline. The tube and wire were electrically insulated from one another. Transformer oil served as the heat transfer medium between the wire, which was the heater, and cylinder. The electric field in the oil was established by imposing voltage differences between the wire and tube. The d c and a c fields were generated by dry cells and an a c source, respectively. The effect of electric field on the heat transfer was indicated by the changes in the Pt wire resistance. The wire current was measured with a standard resistor and a potentiometer and the resistance by a wheatstone bridge which also supplied the heating current.

The heat transfer from the Pt wire to the oil was investigated under the following set of electric field conditions imposed between the wire and tube: (1) Steady d c voltages of either polarity up to 84,000 volts/cm; (2) sudden reversal of d c voltage from one constant value to another of opposite polarity or to zero; (3) sinusoidal 50 cps a c voltage; and (4) a c voltage of varying amplitudes superimposed on a d c voltage.

The test results indicate that d c electric fields decrease the heat transfer whereas a c voltages alone increase it. Combining the a c and d c voltages resulted in (1) no change, (2) an improvement, or (3) a reduction in the heat transfer, depending on the relative magnitude of each type of voltage.

The work of other investigators is analyzed and discussed in the light of the findings of this paper. There are some omissions in the paper which would have made the paper more informative for the reader. No mention is made as to the vertical or horizontal alignment of the test cell although the figure of the cell implies a vertical position. The heat-transfer mechanism was probably natural convection though not specifically stated. Also it is not immediately apparent if the convection is laminar or turbulent. The temperature conditions should have been included. In spite of these shortcomings, the paper does accomplish its stated aim of clarifying the nature of the electric field influence on the convective heat transfer.

As stated in the paper the results can be fruitfully applied to improving the heat transfer in industrial equipment which handles oil and other organic liquids. J. M. Savino, USA

4222. Pergament, H. S., and Epstein, M., Approximate method for determining laminar heat transfer rates, *ARS J.* **30**, 2, p. 206 (Tech. Notes), Feb. 1960.

Lees' result for the hypersonic laminar heat transfer around blunt-nosed bodies of revolution has been applied to bodies of various shapes. It was found that if an appropriately defined heat-transfer parameter is plotted against surface inclination angle, then, for a given free-stream Mach number, the resulting curves are almost independent of body shape.

From authors' summary

4223. Wisniewski, R. J., Methods of predicting laminar heat rates on hypersonic vehicles, NASA TN D-201, 36 pp., Dec. 1959.

"A summary of some of the simplest and best available laminar heat-transfer theories for flow in thermodynamic equilibrium is presented. In some cases the effects of frozen flow are included. Emphasis is placed on the proper methods of obtaining heating rates to hypersonic bodies, wings and control surface. The effects of yaw and the determination of the inviscid flow field are also considered."

No attempt has been made to be overly rigorous in the presentation of these results. The engineering equations presented here, however, should enable one to predict adequately the laminar heating rates on hypersonic vehicles. W. Squire, USA

4224. Seban, R. A., Emery, A., and Levy, A., Heat transfer to separated and reattached subsonic turbulent flows obtained downstream of a surface step, *J. Aero/Space Sci.* **26**, 12, 809–814, Dec. 1959.

Paper is an additional contribution in a series by the University of California (Berkeley) group on heat transfer in separated flows. Heat transfer and recovery factors are presented for the separated and reattached regions downstream of a rearward-facing step. Two step heights were investigated at velocities ranging from 150 to 500 fps, stagnation pressures near atmospheric, and a stagnation pressure of 90° F. Additional results are given for a separated and reattached flow produced by a rod placed on a flat plate.

Results show that the recovery factors were significantly lower than those associated with flat-plate turbulent flows. The heat transfer coefficient was a maximum at the reattachment point.

Reviewer directs attention to paper by H. K. Larson, "Heat transfer in separated flows" [*J. Aero/Space Sci.* **26**, 11, 731–738, Nov. 1959] which augments present paper. Larson qualitatively confirms certain results.

R. W. Van Aken, USA

4225. Conti, R. J., Heat-transfer measurements at a Mach number of 2 in the turbulent boundary layer on a flat plate having a stepwise temperature distribution, NASA TN D-159, 27 pp., Nov. 1959.

A stepwise temperature distribution over a flat plate is produced in a wind tunnel by sudden withdrawal of a cover over part of the plate. The sharp increase (up to 90%) of the heat-transfer coefficient is compared with the isothermal case. Measurements made under near equilibrium conditions show that Ferrari's theory applies and that when the ratio of actual to adiabatic wall temperatures lies between 0.6 and 1.4 and under supersonic conditions, the simpler incompressible theory lies within 2% of experimental values. The streamwise distribution of heat-transfer coefficient is similar to the isothermal plate case if the leading edge were coincident with the location of the step. Special computational techniques are employed to correct experimental values for effects of streamwise and transverse heat conduction.

P. Savic, Canada

4226. Weltmann, Ruth N., and Kuhns, P. W., Heat transfer to cylinders in crossflow in hypersonic rarefied gas streams, NASA TN D-267, 24 pp., Mar. 1960.

Heat-transfer rates and temperature-recovery ratios were measured on cylinders in crossflow in a low-density wind tunnel for three gases of different molecular weight and accommodation coefficient at hypersonic Mach numbers. The accommodation coefficient was 0.9 for nitrogen, 1.0 for argon, and 0.4 for helium. The data extend from free-molecule to almost continuum flow and cover ranges of Knudsen, Nusselt, and Reynolds numbers of $0.001 \leq Kn \leq 15$, $0.01 \leq Nu \leq 10$, and $0.1 \leq Re \leq 1000$. The data indicate that the accommodation coefficient is the predominant variable affecting heat transfer in the free-molecule-, transition-, and slip-flow regimes.

From authors' summary

4227. Cybulski, R. J., and Baldwin, L. V., Heat transfer from cylinders in transition from slip flow to free-molecule flow, NASA Memo 4-27-59E, 49 pp., May 1959.

With 5-micron tungsten hot-wires in a variable-density, low turbulence tunnel, data for heat transfer to air have been obtained for Mach between 0.1 and 0.9 and Reynolds between 0.03 and 11.5. As the Knudsen number varied from 0.1 to 5.0, the Nusselt number correlation derived should be generally valid for subsonic flow in the region from slip flow (Knudsen < 2) to fully developed free-molecule flow (Knudsen > 2). The present wire recovery-temperature data, however, indicate that free-molecule flow will only be fully developed at Knudsen about 5 and higher, which is beyond the experimental range tested.

J. K. Yap, Holland

4228. Krzywoblocki, M. Z., and Bergonz, F. H., On some problems of heat transfer in free molecule flow, *Acta Physica Austriaca* **12**, 4, 400–411, Aug. 1959.

Expressions for the heat transferred to cones and paraboloids of revolution are found assuming that the flow is axisymmetric and all of the energy of the molecules is translational kinetic energy. Calculations of surface temperature and heat transfer are then carried out for a cone whose semivertex angle is 30° and for a paraboloid of the same surface area and same total angle, assuming total accommodation. Ambient air conditions correspond to altitudes of 75 to 150 miles and Mach numbers range from 0 to 20. The resulting curves of temperature versus Mach number, altitude and heat transferred are extended well into the region of negative temperature ratio. This region does not have any physical meaning, unless there has been some error in labeling of the temperature scale. Also no explanation is given for the discrepancy between the expression for heat transferred to the cone and the previously published expression, AMR **6** (1953), Rev. 2846 or Vol. 3 of the series "High-Speed Aerodynamics and Jet Propulsion."

R. E. Street, USA

4229. Levey, H. C., Heat transfer in low Reynolds number slip flow, Aero. Res. Lab., Melbourne, Austral. Rep. A. 112, 12 pp., Mar. 1959.

The transfer of heat by forced convection from a hot wire in a low Mach number rarefied gas stream is investigated for small Reynolds numbers. A simple expression is found for the Nusselt number and it is suggested that this has reasonable validity over a wide range of Knudsen numbers, even into the free-molecule flow regime. From author's summary

4230. Hatch, J. E., and Papell, S. S., Use of a theoretical flow model to correlate data for film cooling or heating an adiabatic wall by tangential injection of gases of different fluid properties, NASA TN D-130, 43 pp., Nov. 1959.

An adiabatic wall adjacent to a hot gas stream may be cooled by admitting a thin film of cold gas tangentially to the surface in the

direction of the stream. Previous work has been limited to air admission and to low stream temperatures, and is not readily applicable in design.

Authors used helium and air, covering ranges of main stream temperature up to 1965 R, velocity 104 to 1040 fps, injected gas to 980 R, and slot height 0.063 to 0.5 inches. A simple model consisting of the coolant film as an unmixed layer was analyzed, yielding an equation for wall temperature-recovery factor in terms of down-stream distance and the other variables. All results with both gases were correlated within about 5%, indicating the generality of the equation.

C. F. Bonilla, USA

4231. Stepka, F. S., and Richards, H. T., Experimental investigation of metal temperatures of air-cooled airfoil leading edges at subsonic flow and gas temperatures up to 2780° F, NASA TN D-127, 32 pp., Nov. 1959.

The cooling characteristics of the leading edges of air-cooled symmetrical airfoils were investigated in a flow tunnel at high gas temperatures. Three configurations of internally cooled leading edges representative of the leading edges employed in air-cooled turbine blades were investigated. Two of the configurations were fabricated from sheet metal, and the third was a casting. The effect of conduction on leading-edge cooling was determined by independently cooling the afterbody of the airfoil. The investigation was conducted over a range of total gas temperature from 1660 to 2780 F, while the cooling-air inlet temperature was maintained constant at approximately 80 F. The reference temperature of the airfoil afterbody ranged from 600 to 1675 F. Average gas Reynolds number for the leading edges ranged from 4700 to 18,000, and gas Mach number ranged from 0.29 to 0.71. The cooling-air inlet Reynolds number was between 2700 and 23,000, and the cooling airflow ranged from 0.0006 to 0.0044 pound per second.

The experimental results indicated that the cast-leading-edge configuration cooled less effectively than the sheet-metal-fabricated leading-edge configurations. The average and maximum temperatures of the leading-edge regions of the sheet-metal-fabricated configurations showed greater response to a change in afterbody temperature than did the temperatures of the cast-leading-edge configuration. At an effective gas temperature of 2320 F, a gas Reynolds number of 9000, and a cooling airflow to the leading edge of 0.003 pound per second, the ratio of a change in either the average or maximum metal temperature of the leading edge to a change in afterbody temperature was approximately 0.23 for the cast-leading-edge configuration and 0.36 for the sheet-metal-fabricated configuration. At these same conditions, the average metal temperature of the cast-leading-edge configuration was approximately 200 F higher than the sheet-metal-fabricated configuration. A method of correlating the average metal temperatures of the leading edges was evolved which permits use of the experimental data at other than test conditions. The leading-edge temperature data for each of the configurations considered correlated about a mean line through the data within ±10%.

From authors' summary

4232. Weinstein, M. A., On the validity of Kirchhoff's law for a freely radiating body, *Amer. J. Phys.* **28**, 2, 123-125, Feb. 1960.

In applying Kirchhoff's law to calculate the emission of a heated body radiating freely to the outside, one assumes that the emission of a body when radiating freely is the same as its emission when enclosed in a blackbody cavity. But the radiation field inside the body is everywhere smaller in the first case than in the second; consequently the emission arising from induced radiative transitions must be smaller for a freely radiating body than the emission arising from these transitions when the body is enclosed in a cavity. Since the emissions differ, one is apparently led to the conclusion that Kirchhoff's law cannot be valid for a freely radiating body. It is shown that this conclusion is false; Kirchhoff's law is valid as long as the distribution over material states is the equilibrium distribution, and is therefore, in this sense, independent of the state of the radiation field. One must, however, take proper account of the effect of induced emission in calculating the absorption coefficient.

From author's summary

4233. Dunkle, R. V., Ehrenburg, F., and Gier, J. T., Spectral characteristics of fabrics from 1 to 23 microns, *ASME Trans.* **82** C (*J. Heat Transfer*), 1, 64-70, Feb. 1960.

Spectral reflectance data were reported for 19 types of natural, synthetic, and regenerated textiles used as clothing materials. The estimated error was about ±0.03 in the reported reflectance. These data may be used to predict the total radiant properties for sources of any spectral distribution.

W. L. Sibbitt, USA

4234. Lieblein, S., Analysis of temperature distribution and radiant heat transfer along a rectangular fin of constant thickness, NASA TN D-196, 60 pp., Nov. 1959.

During space flight a certain amount of internally generated heat (i.e., not resulting from external friction) will have to be dissipated. Part of this may be absorbed by fuel, but most must be radiated to space. This paper analyzes dissipation possibilities of rectangular fin of constant thickness with uniform heat source at leading edge. Results are generalized and made applicable to different environments by definition of equivalent environmental sink temperature. Heat radiated depends on a number of factors; principal one is source temperature. Sink temperature has relatively small effect on radiation, but large effect on temperature profile in fin. Various design parameters are derived and application to practical problems is indicated.

In reviewer's opinion, this is one of a large number of similar studies which will be made by various investigators before applications of contemplated type are required, and consensus of these studies will guide selection of methods eventually used.

C. W. Smith, USA

4235. Sparrow, E. M., and Gregg, J. L., The effect of vapor drag on rotating condensation, *ASME Trans.* **82** C (*J. Heat Transfer*), 1, 71-72 (Technical Briefs), Feb. 1960.

In a previous paper [AMR **12** (1959), Rev. 6287] zero shear at the interface between liquid and vapor was assumed. The new extension of the analysis includes the vapor motion induced by the rotation of the disk. The ratio between the values of $\rho\mu$ for liquid and vapor is introduced as a new parameter. The numerical result that, depending on the liquid film thickness, the vapor drag may either slightly increase or decrease heat transfer is discussed. The effect on heat transfer exceeds 3% only if the governing parameters are in the range for liquid metals; in this case the decrease amounts to 11%. However, in a few examples the drag increases the torque required to rotate the disk by as much as 100%.

H. A. Vreedenberg, Holland

4236. Engelberg-Forster, K., and Greif, R., Heat transfer to a boiling liquid—mechanism and correlations, *ASME Trans.* **81** C (*J. Heat Transfer*), 1, 43-53, Feb. 1959.

Existing proposed mechanisms of nucleate boiling heat transfer, such as microconvection in the laminar sublayer, surface roughness, and latent heat transport by bubbles, are briefly reviewed and a new vapor-liquid exchange mechanism is proposed. Limitations of older theories are discussed along with evidence in favor of the vapor-liquid exchange, which essentially assumes a "pumping" of the liquid by bubble action through the boundary layer. This mechanism shows the nucleate boiling heat-transfer rate to be strongly influenced by the size and rate of bubble formation. Since subcooling of the liquid has been found by others to both decrease the bubble radius and increase the bubble formation rate, the new mechanism shows how these two effects tend to

compensate one another and to give a nucleate boiling heat transfer relatively independent of the degree of subcooling of the liquid; this is in agreement with experimental findings. A general equation is given for calculating nucleate boiling heat transfer in terms of the basic physical properties of the fluid such as surface tension, latent heat of vaporization, thermal conductivity, specific heat, density, viscosity, and saturation temperature. Correlation with some experimental results is given.

In the reviewer's opinion a reasonable mechanism of nucleate boiling heat transfer is presented along with an approximate method for correlating the numerous independent variables in the problem; although the accuracy for general use of the equation is yet to be established, it provides an approximate method for theoretical prediction as well as indicating the relative importance of the various physical properties of the fluid on the heat transfer rate.

R. D. Turncliff, USA

4237. Aerov, M. E., Nikitina, N. I., Trainina, S. S., and Gusev, I. V., Heat-mass exchange in a granular layer, *Soviet Phys.-Tech. Phys.* **4**, 7, 837–840, Jan. 1960 (Translation of *Zh. Tekh. Fiz., USSR* **29**, 7, 924–927, July 1959 by Amer. Inst. Phys., New York, N. Y.

Local coefficients of mass exchange in a layer of balls for Reynolds number $Re = 40$, 300, and 3000 were measured.

From authors' summary

4238. Lancashire, R. B., Lezberg, E. A., and Morris, J. F., Experimental results of a heat-transfer study from a full-scale pebble-bed heater, NASA TN D-265, 22 pp., Mar. 1960.

Data were obtained from the initial operation of a large regenerative pebble-bed heat exchanger in order to determine the heat-transfer characteristics of a packed bed of spheres. The facility, designed to produce high-temperature air for hypersonic flight research, is described in detail. The heat-transfer analysis and results are presented and compared with those of other investigators.

From authors' summary

4239. Garner, F. H., Kendrick, P., and Lane, J. J., Mass transfer to drops of liquid suspended in a gas stream, Parts 1 and 2: A wind tunnel for the study of individual liquid drops; Experimental work and results, *Trans. Inst. Chem. Engrs.* **37**, 3, 155–172, June 1959.

Photographic and chemical analyses were made of different size droplets of different liquids falling through gases in a vertical wind tunnel. Internal circulation was steady and shown to cause a large increase in rates of gas absorption. Carbon dioxide and water were absorbed by a number of liquid drops. Frequency of oscillation was found to agree with formulas given by Lamb. The experimenters were able to keep the drops in view for as long as 20 seconds in the case of carbon dioxide and for over 10 minutes in the case of water absorption. It was possible to show how the change in internal circulation affected the rates of water absorption or carbon dioxide absorption.

M. Tribus, USA

4240. Mark, H. J., Mass transfer in the laminar boundary layer along a flat plate calculated by means of the integral method, *Appl. Scient. Res.* (*A*) **8**, 4, 261–277, 1959.

The integrated boundary-layer equations are used to calculate friction and mass transfer for flow of a two-component gas mixture over a flat plate. The product of density times viscosity and the Schmidt number are assumed constant in these equations. The velocity and concentration profiles are represented by polynomials of the fourth degree. The calculation, which becomes rather involved, has been carried out for Schmidt numbers between 0.1 and 100 and for a large range of the form parameter for the concentration profile which depends on the strength and the direction of the mass flow at the solid surface. The ratio of the actual dimensionless mass transfer number to the mass transfer number for vanishing mass transfer varies between 0 and 2.5 for Schmidt numbers larger than one. It is found to depend only moderately on the value of the Schmidt number. The ratio of the actual friction factor to the friction factor at vanishing mass transfer, on the other hand, is strongly influenced by the form parameter for the concentration profile. For a Schmidt number equal to one, the ratio has the same value as the ratio of the mass transfer parameters; whereas for a Schmidt number equal to infinity, the ratio has the constant value one, independent of the form parameter. Comparisons with previous calculations by Eckert and Lieblein, using a third-degree polynomial, and with exact calculations for some values of the Schmidt number, indicate good agreement except for large negative values for the form parameter. It is pointed out that a different method by Meksyn leads more rapidly to results than the integral method.

E. R. G. Eckert, USA

4241. Mark, H. J., Mass transfer in laminar boundary layers calculated by means of a perturbation method, *Appl. Scient. Res.* (*A*) **8**, 4, 237–260, 1959.

Mass transfer in laminar boundary layers is analyzed with the following assumptions: Thermal and pressure diffusion are small, no body forces are present, Mach number is small, and the system consists of a binary gas mixture. Various boundary conditions at the surface are accounted for by introduction of Spaldings mass-transfer parameter B. A relation between heat transfer and mass transfer is obtained for a Lewis number equal to one. It differs from previously published relations by an additional term accounting for the dependence of enthalpy on concentration. The boundary-layer equations are then solved under the additional restrictions that the product of density times viscosity and the Schmidt number are constant within the boundary layer. The solution is obtained by a perturbation method expanding the solution in terms of B for small values of B and by a series expansion for large values of the Schmidt number and for any value of B. A comparison of the results obtained demonstrates that the ratio of the actual mass-transfer parameter to the mass-transfer parameter for the limiting situation $B = 0$ depends very little on Schmidt number. It agrees very well with previously published results.

E. R. G. Eckert, USA

4242. Spalding, D. B., Graphical method of calculating heat transfer, condensation, and vaporization rates in processes involving water-steam-air mixtures, *Proc. Instn. Mech. Engrs.* **172**, 28, 839–864, 1958.

This paper presents a graphical method for the calculation of heat and mass transfer rates in processes involving air and water in direct contact. Authors use an enthalpy-concentration diagram showing properties of the chart and graphical procedures to use at local points in an air-water system. Effect of σ (a number expressing the ease of heat transfer relative to mass transfer) is considered, as well as magnitude of overall heat-transfer coefficient and of radiative heat transfer.

Mass energy balances for a single contact stage are worked out graphically for various types of flow of one fluid relative to the other. Wet and dry bulb hygrometry, drying, condensation, cooling towers, gas coolers, and trickling coolers are considered.

The graphical method in most cases does not require the interative techniques of previously published methods, but for good accuracy a large detailed enthalpy-concentration graph is needed. Method can be extended to other systems and other processes.

J. G. Knudsen, USA

4243. Hauser, W., Heat transfer in bodies of microscopic life (in German), *Naturwissenschaften* **45**, 5, 105–106, Mar. 1958.

Combustion

(See also Revs. 4261, 4262, 4268)

4244. Dalmai, G., Contribution to the study of flame propagation in closed tubes (in French), *Rev. Inst. Fr. Petrole et Ann. Liquid* **13**, 12, 1683–1722, Dec. 1958.

Methane-air, propane-air, and butane-air mixtures were ignited with sparks in open and closed Pyrex tubes. Nitrous oxide was used as oxidant in one test series. The following conditions were varied: gas composition and initial pressure, tube length and diameter, electrode spacing spark energy and method of energy dissipation, tube wall treatment (etching with HF, CaO coating, PbO coating, colloidal platinum deposit), tube orientation, open versus closed tube. For each set of conditions the following results were observed: flammability, burned gas composition (if flammable), flame appearance.

Part of the experimental results are presented as flammability limits on diagrams of initial pressure versus percentage of combustible in the unburned mixture. For ignition in closed vertical tubes with a series of sparks, the flammable region was found to be separated into two lobes by an indentation occurring at certain combustibles concentrations. The depth of this indentation increased with increasing tube-length-to-diameter ratio. For open vertical tubes and for ignition with single sparks, no such indentation was found. In horizontal tubes the combustibles-rich lobe of the flammable region vanished. Different tube wall treatments had no significant effect on the flammability limits.

The possible causes behind these complex phenomena are discussed at great length, but the experimental results are reported only incompletely and without full identification of experimental conditions.

A. W. Gessner, USA

4245. Scholte, T. G., and Vaags, P. B., Burning velocities of mixtures of hydrogen, carbon monoxide and methane with air, *Combustion and Flame* **3**, 4, 511–524, Dec. 1959.

The burning velocities of mixtures of hydrogen-carbon monoxide, hydrogen-methane and carbon monoxide-methane with air were determined. These are maximum at a given gas/air ratio. The maximum burning velocities and the corresponding gas percentages are given as functions of the gas composition. The burning velocities of the various hydrogen-carbon monoxide-methane mixtures with air were also measured. The maximum burning velocities and the corresponding gas percentages of all hydrogen-carbon monoxide-methane mixtures are presented in a triangular diagram. Furthermore a determination was made of the effect of smaller amounts of nitrogen, carbon dioxide and oxygen on the maximum burning velocity and on the corresponding gas percentage.

From authors' summary

4246. Scholte, T. G., and Vaags, P. B., The burning velocity of hydrogen-air mixtures and mixtures of some hydrocarbons with air, *Combustion and Flame* **3**, 4, 495–501, Dec. 1959.

An apparatus is described by which the burning velocity of gas-air mixtures can be measured with an accuracy of about five per cent. The apparatus has been used for measuring the burning velocity of hydrogen-air mixtures and mixtures of methane, ethane, propane, *n*-butane, acetylene, ethylene, propylene and *n*-butylene with air as a function of the gas-air ratio.

From authors' summary

4247. Scholte, T. G., and Vaags, P. B., The influence of small quantities of hydrogen and hydrogen compounds on the burning velocity of carbon monoxide-air flames, *Combustion and Flame* **3**, 4, 503–510, Dec. 1959.

The dependence of the burning velocity of carbon monoxide-air mixtures on small admixed quantities of hydrogen, hydrogen compounds and deuterium has been measured. It was found with carbon monoxide-hydrogen mixtures that the square of burning velocity equals the sum of the square of the burning velocity of pure carbon monoxide and a term proportional to the hydrogen content. With added hydrogen compounds or deuterium a similar relation is valid.

From authors' summary

4248. Edwards, D. H., Williams, G. T., and Breeze, J. C., Pressure and velocity measurements on detonation waves in hydrogen-oxygen mixtures, *J. Fluid Mech.* **6**, 4, 497–517, Nov. 1959.

The Chapman-Jouguet (C-J) plane in an ideal detonation is presumed as the state of thermal equilibrium after completion of detonative reaction. Authors examined whether or not the real detonations of hydrogen-oxygen mixtures in 10-cm and 1.6-cm tubes are the ideal detonations by measuring detonation pressures as well as velocities and conclude that except for the range of 50–75% of hydrogen in 10-cm tube the real detonations are not ideal. This imperfection is ascribed to the rarefaction wave which starts at the wall due to its cooling effect and lets the pressures and rates of reaction decrease.

Authors also obtained the double-peak figure of reflection pressure of detonation waves. The first peak is obviously due to the von Neumann spike. The second peak is explained by authors as corresponding to the second shock originated from the C-J plane, but reviewer thinks this explanation is not self-evident and needs more study.

T. Hikita, Japan

4249. Norkin, N. N., An equation for calculating the length of cone of the flame of an air-draft burner (in Russian), *Trudi Tomskogo In-ta* **145**, 127–130, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8477.

Experiments have been made with diffusor burner nozzles of varying diameters, burning water gas. A relationship has been established between the overall length L and the ratio w/a of the rate of outflow of the combustion mixture from the burner w, to the rate of propagation of the flame u, to the value of the Reynolds number:

$$R\frac{L}{Ad^n m} = \frac{w}{u}$$

where d = burner diameter, $A = 0.535$, $n = 1.9$, $m = 1$ for laminar flow ($m = (R/2320)^{0.5}$ for turbulent flow). In addition, a similar relationship has been obtained for the length of the kinetic part of the cone (i.e., the length of the internal flame front).

Yu. F. Dityakin

Courtesy Referativnyi Zhurnal, USSR

4250. Peshkin, M. A., The effect of pressure on the lower limit of concentration for the breakaway of a flame in a flow (in Russian), *Zh. Fiz. Khimii* **31**, 12, 2757–2758, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 9583.

Paper explains the extension of the lower limits of steady-state combustion in the case of established turbulence in the flame front. According to the conceptions of the thermal theory of flame propagation, the variation in the limiting concentration for breakaway of the flame in the presence of a varying pressure can be shown by the equation

$$\frac{\alpha_1}{\alpha_2} = \frac{P_1}{P_2}^n$$

where α is the excess coefficient in the combustion mixture, P is pressure, and the exponent n depends on the processes of gas motion and heat transfer near the flame front.

V. I. Iagodkin

Courtesy Referativnyi Zhurnal, USSR

4251. Shchelkin, K. I., Two cases of unstable combustion, *Soviet Phys.-JETP* **9**, 2, 416–420, Aug. 1959. (Translation of *Zh. Eksp. Teor. Fiz., SSSR* **36**, 600–606, Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.).

In the first case, a detonation wave is considered in which the compression front does not coincide with the plane at which the combustion is completed (heating front) due to the relaxation time of the chemical reactions. (However, it is still assumed that the chemical reactions take place instantaneously so that the pressure is constant during this induction period.) Because of the nonuniformity of the burning mixture entering the flame zone, a perturbation at the flame front may develop. This causes a gas motion perpendicular to the wave motion and expansion waves will travel into the flame zone with the higher pressure and compression waves into the region of lower pressure. Therefore, the flame front loses its stability and also the compression front is disturbed due to the rarefaction waves. Since the original perturbation and the following disturbances must be considered as random processes, the compression front will have "wrinkles," which form and disappear at random ("pulsating brush"). Under the condition that the reaction zone thickness is one-third or greater than the tube diameter, only one single-headed spin detonation exists.

In the second case the above-treated instability of the flame zone serves to explain qualitatively high frequency vibrations in forced combustion chambers (rockets, etc.).

C. B. Ludwig, USA

4252. Druskin, L. I., Ivanov, V. M., and Kantosovich, B. V., Temperature calculations for ducted gas burners (in Russian), *Stal* no. 10, 951–957, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8576.

The results are given of an experimental investigation into the combustion process in a fuel gas in a fireclay duct burner. The high efficiency of combustion on the condition of thorough mixing of the gas with the combustion air, the presence of intermediate combustion products (methyl alcohol, formaldehyde) in the temperature range of 1000–1500°, and the possibility of analytical determination of the concentrations and temperatures along the burner (using a special, experimental constant) are mentioned.

G. A. Varshavskii

Courtesy Referativnyi Zhurnal, USSR

4253. Caffier, E., Problems in experiments on annular combustion chambers (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 410–416.

The following problems are considered which arose in the development of an annular combustion chamber for an aircraft gas turbine:

The achievement of uniform air velocity at the entry to the combustion chamber.

The achievement of good flame stability over the whole operating range.

Reignition at great heights.

High combustion efficiency over a wide range of operating conditions.

Low pressure drop.

Uniform temperature distribution at the entry to the turbine, and satisfactory mechanical properties.

Two types of burners are described, each forming a ring of burners around the annulus, one called the cone burner, and the other the star burner, and some very carefully prepared isobars and isotherms are shown which must have involved a very great deal of experimental work. The final diaphragm combustion chamber developed by SNECMA is considered to solve all the problems laid down.

M. W. Thring, England

4254. Simmons, F. S., Expansion of liquid-oxygen Rp-1 combustion products in a rocket nozzle, *ARS J.* **30**, 2, 193–194 (Tech. Notes), Feb. 1960.

Gas temperature measurements at the nozzle exit of a rocket motor utilizing liquid oxygen and RP-1 have been made over a wide range in propellant mixture ratio. The assumption of a nozzle flow process consisting of a frozen composition expansion with some additional burning is shown to be in reasonable accord with the observed motor performance.

From author's summary

4255. Tamura, Z., and Tanasawa, Y., Evaporation and combustion of a drop contacting a hot surface, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 509–522.

Photographic studies were made of the rate of vaporization in air of fuel droplets impinging on a heated concave surface. Initial diameters were in the range of approximately 1 to 3 mm. With increasing surface temperature five stages of the droplet mass transfer can be classified: gradual evaporation, internal nucleate boiling, maximum boiling rate, Leidenfrost spheroidal evaporation, and, finally, spheroidal combustion. A curve similar to that for pool-boiling heat transfer was obtained when lifetime of a droplet was plotted versus surface temperature. Fuels included in the study were: benzene, *n*-heptane, isooctane, *n*-cetane, α-methylnaphthalene, ethyl alcohol, water, gasoline, kerosene, heavy oil A.

D. M. Mason, USA

4256. Bassevich, V. Ia., Turbulent diffusion and the combustion of a pulverized fuel in a fluid flow (in Russian), *Zh. Fiz. Khimii* **31**, 7, 1619–1627, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8976.

From an approximate analysis of the equations describing the combustion of a droplet of fuel in a turbulent airflow in the presence of an insignificant quantity of the vaporized fuel, the author attempts an answer to the question of which mechanism—molecular exchange, or turbulent diffusion—is the determining factor of the combustion of a pulverized fuel in this flow. It is demonstrated that the rate of combustion of a droplet in a turbulent flow is very little dependent on the particular exchange. However, by evaluating the ratio of the velocities of combustion of the droplet and the gaseous phase of the fuel, in a stream of atomized liquid fuel, for different mechanisms of exchange (molecular diffusion, turbulent diffusion toward a solid wall, and free turbulent diffusion), and comparing the analytical results with experimental data, author is able to demonstrate that the assumption of free turbulent diffusion is qualitatively correct as a description of the process of mass exchange in the reaction zone of a droplet burning in a turbulent flow; the postulate of molecular diffusion of the substance is not justifiable.

O. V. Yakovlevskii

Courtesy Referativnyi Zhurnal, USSR

4257. Westenberg, A. A., and Rice, J. L., Further measurements of turbulence intensity in flame zones, *Combustion and Flame* **3**, 4, 459–465, Dec. 1959.

In a previous paper, a technique for measuring transverse turbulence intensity in flames by means of helium diffusion was described. The intensity is estimated from the concentration distribution of helium (determined by sampling) downstream of a "point source" injection tube immersed in the main stream. Results were reported of the effect of various parameters on the intensity measured at a single location in highly turbulent flames stabilized on baffles in a 2-in. × 8-in. rectangular duct. The present paper contains additional results obtained at several other positions in the same duct. The data include heat-release combustion efficiencies and turbulence intensities under both cold flow and burning conditions for each of two different values of approach flow turbulence intensity (approximately 5% and 10%). Premixed pentane-air at an equivalence ratio of 0.7 and a pressure of 0.85 atm was used. The twofold increase in approach turbulence caused an approximately twofold increase in the rate of flame spreading. By comparing the absolute intensities of turbu-

lence during burning and cold flow it is shown that in regions of actively burning gas the turbulence is higher than in cold flow, but in regions of completely burnt gas the intensity may be reduced and may even become laminar. Cold gas regions adjacent to flame zones are essentially unaffected by the presence of flame.

From authors' summary

Prime Movers and Propulsion Devices

(See also Revs. 3823, 3954, 4127, 4302, 4338)

4258. Tipler, W., The free piston engine, Shell International Petroleum Company Ltd., Oil Products Development Division Rep. 55/59 M, 51 pp., June 1959.

The purpose of this report is to outline the development and working principles of the various types of free piston engine, and to assess their prospects of use in various fields.

From author's summary

4259. Falchi, G., Contribution to calculation of suction stroke in an ideal cycle of reciprocating internal-combustion engines (in Italian), *Termotecnica* **13**, 6, 247–256, June 1959.

4260. Cockshutt, E. P., Levy, G. G., and Sharp, C. R., Turbojet thrust augmentation: Flight measurements of the turbine blade cooling accompanying the pre-turbine injection of reheat fuel with an Orenda 14 engine in a Sabre 6 aircraft, Nat. Res. Counc., Canada LR-271, 41 pp., Jan. 1960.

Turbine blade temperature data, obtained with a thermocouple-slipring instrumentation system, are presented for an Orenda 14 engine, which was flight tested both with and without reheat at altitudes ranging from 20,000 to 50,000 feet. The blade temperatures in the unreheated engine were found to be determined primarily by the variation in the turbine outlet (gas) temperature with flight condition. The first-stage turbine blades were cooled by the pre-turbine injection of the reheat fuel by a maximum of 150 C under sea-level-static conditions; as had been predicted from simple heat-transfer theory, the maximum cooling declined to about half this value at 50,000 feet. No significant cooling of the second-stage turbine blades was detected at any flight condition. The instrumentation system operated without serious difficulties throughout the test program.

From authors' summary

4261. Vandenkerckhove, J. A., Recent advances in solid propellant grain design, *ARS J.* **29**, 7, 483–491, July 1959.

Author discusses end-burning and side-burning grains, and noncylindrical grains. Geometrical configurations of these are illustrated. For long burning times web thickness can be slightly increased to $w = 0.7\ R_c$ and chamber pressure can be lowered somewhat. Burning times in excess of 30 seconds can be achieved with small-diam side-burning grains. For shorter times the web can be reduced. Internal ballistics are discussed. Designs of fundamentals are reviewed, along with environmental thermal stresses, bonding, and other stresses. Analytical techniques are used in the paper.

Reviewer believes this subject has been amply covered in other recent works by Americans. C. J. Dezeih, USA

4262. Visnov, M., The useful life of solid propellants at very high temperatures, Part I, *ARS J.* **29**, 7, 500–505, July 1959.

The heat arising from operational environments of supersonic aircraft and missiles creates new problems of reliability and survival of propellant-powered or cartridge-activated devices (CAD's). Some of the problems concern materials (such as structural and shape integrity), and controlled rates of decomposition into specified volumes of gas. Some of the factors involved include: location of devices; high-temperature extension; recycling; packaging; protection.

CAD's mounted within inches of skins aggravate the problems. For example, some have to withstand environments of 500 F for periods in excess of 4 hours in operative phases, while others (in parked aircrafts) may be exposed to temperatures over 200 F while inoperative through a series of cycling.

Some specifications for CAD's require packaging such that the sealed cartridge case must withstand 14 psi pressure differential. At elevated temperatures the decomposition rate of many propellants would be accelerated.

While it is possible to protect against heat by using thermal insulation, space allotments are insufficient to permit such design usage.

During the course of investigations by the R & D Group of Frankfort Arsenal, certain observations were made. Present nitrate esters do not meet the new high-temperature requirements for propellant-actuated devices. Composite propellants show promise up to 400 F for moderate durations, although problems still exist. Small geometries are necessary, but these are difficult to obtain along with small-size grains. A very difficult problem is that of an acceptable temperature coefficient of performance over a temperature spread of about 460 F.

The studies are continuing. C. J. Dezeih, USA

4263. Kramer, J. L., Lowell, H. H., and Roudebush, W. H., Numerical computation of aerodynamic heating of liquid propellants, NASA TN D-273, 28 pp., Apr. 1960.

A detailed numerical procedure, with an accompanying flow diagram, is presented for a digital computer program to compute the aerodynamic heat input to liquid rocket propellants. The effect of a finite heat-transfer coefficient between the liquid propellant and the tank wall is taken into account. Illustrative examples are presented. From authors' summary

4264. Bragg, S. L., Performance problems in large rocket engines, *J. Roy. Aero. Soc.* **64**, 591, 131–140, Mar. 1960.

4265. Jones, W. L., Price, H. G., Jr., and Lorenzo, C. F., Experimental study of zero-flow ejectors using gaseous nitrogen, NASA TN D-203, 23 pp., Mar. 1960.

Experimental models of straight-tube and second-throat zero-flow ejector types were studied to determine the performance and optimum design for use with rocket engines. Both bell-shaped and 15°-conical primary nozzles with area ratios of 25 : 1 were used, as was a second conical nozzle with 50 : 1 area ratio. Both ejector types were investigated over a range of area ratios and length-to-diameter ratios. Second-throat ejectors were studied at several contraction angles. Experimental maximum ejector contraction area ratios and starting performance are given for a range of ejector inlet Mach numbers from 1 to 10.

From authors' summary

4266. Alford, W. J., Jr., and Goodson, K. W., A technique for firing dynamically scaled missile models in wind tunnels and for measuring rocket-motor sound and pressure fluctuations, NASA TN D-224, 43 pp., Mar. 1960.

The dynamic-similarity laws are reviewed and found to be applicable to both constant Mach number scaling and constant Froude number scaling. Rocket motors were designed that provided reasonable scaled thrust time histories. The photographic instrumentation was adequate for obtaining flight-path records of the missiles under conditions of high longitudinal velocity. Rocket-motor noise measurements were made at three microphone locations (streamwise) on the lower surface of the wing as the missile traversed the wing. From authors' summary

4267. Hall, J. G., Eschenroeder, A. Q., and Klein, J. J., Chemical nonequilibrium effects on hydrogen rocket impulse at low pressures, *ARS J.* **30**, 2, 188–190 (Tech. Notes), Feb. 1960.

4268. Lowell, H. H., Dispersion of jettisoned JP–4 jet fuel by atmospheric turbulence, evaporation, and varying rates of fall of fuel droplets, NASA TN D–84, 25 pp., Oct. 1959.

To answer the question, "Do combustible mixtures occur when fuel is jettisoned?" a mathematical model is formulated. Three aspects of the problem treated are: varying rates of fall due to different drop sizes, dispersion due to atmospheric turbulence, and evaporation of droplets. Wind conditions influence turbulent diffusion of drops; quiet and gusty days are considered. Temperature influences evaporation rates; cold (−39°C) and warm (21°C) days are also considered. Approximate calculations are performed for the four possible combinations of wind and temperature. The calculations indicate that if the aircraft is above 500 feet, a combustible mixture will not be formed if jettisoning occurs at rates expected for current jet transports. A. Fuhs, USA

4269. Lutz, O., Buschulte, W., and Mose, K., Nomograms for the computation of jet engines (in German), Dtsch. Forschungsanstalt Luftfahrt, Ber. 113, 31 pp., July, 1959.

4270. Shepherd, L. R., Electrical propulsion systems in space flight (in English), *Astronaut. Acta* **5**, 2, 144–157, 1959.

It is suggested that the available maximum acceleration of electrically propelled space vehicles should not be less than a milligee and that such an acceleration might be coupled with a specific impulse of about 10,000 seconds. This implies that the specific mass of power plant must be kept as low as 0.5 tons per megawatt. The contribution of the mass of a nuclear reactor to the total power plant mass should lie well within this figure. Provided that the surface temperature of the waste heat radiator is greater than 700 K, if one neglects the possibility of meteor penetration, the radiator mass may be acceptable. However, 700 K is excessive as a compressor inlet temperature in a gas turbine power plant and two-phase power systems working on a Rankine cycle might be necessary with such a high sink temperature. These, however, may have other undesirable features which could rule them out in this application.

Existing electrical generating equipment is far too massive for application to propulsion of space vehicles, but the development of an electrostatic generator might result in sufficiently light equipment. In the long run, however, it is suggested that a radical departure from conventional methods is demanded and one possibility lies in the development of a plasma generator in which nuclear energy is used to heat up a plasma which expands through a magnetic field. The work done by the plasma would appear directly as electrical energy.

It is suggested that for the production of relatively low specific impulses of 10,000 seconds or less a magnetic accelerator which accelerates a neutral plasma may be superior to the conventional accelerator in which separated positive ions are accelerated in an electrostatic field. The possibility of a vehicle utilizing a plasma generator coupled to a magnetic accelerator using sodium as a propellant is envisaged in the paper. From author's summary

Magneto-fluid-dynamics

(See also Revs. 4064, 4182, 4221, 4270)

4271. Ladizhenskii, M. D., Flow problems in magnetohydrodynamics, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23**, 2, 419–427, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Author examines in very general terms the flow around a body from whose interior a magnetic field is excited. The fluid is electrically conducting. The system of equations consists of equation of motion, continuity, and Maxwell's and Ohm's laws.

The fluid is incompressible, the coefficients of viscosity and electrical conductivity are constant, the magnetic permeability is equal to unity. At infinity the velocity vector and pressure are given, the intensity of the magnetic and electric fields reduce to zero. Author proves that there is a no-slip condition between the outer and inner magnetic fields. Moreover, the current cannot flow through the surface, which condition is fulfilled automatically for finite magnetic Reynolds, R_m, number. Author outlines the procedure and the necessary steps to be taken in solving the system in question. The magnetic field alters the flow around the body and the hydrodynamic force. In addition, there appears a magnetic force whose magnitude is calculated by using the general Ostrogradsky formula and by integration over the surface of the body.

Next, the flow around bodies at large values of R_m is discussed. In a flow around bodies there appears a magnetic boundary layer which in all cases of interest is much thicker than the viscous layer. This makes it possible to omit the viscous terms in the equations of motion. With this observation, the author puts down equations with the usual boundary-layer assumptions, whose solution is briefly outlined. The integration of the pressure term around the body furnishes D'Alembert's paradox, the magnetic force (different from zero) furnishes the magnetic drag coefficient containing a constant which depends upon the geometry of the body and the geometry of the magnetic source distribution.

M. Z. v. Krzywoblocki, USA

4272. Yosinobu, H., and Kakutani, T., Two-dimensional Stokes flow of an electrically conducting fluid in a uniform magnetic field, *J. Phys. Soc. Japan* **14**, 10, 1433–1444, Oct. 1959.

Drag of an infinite circular cylinder is computed as a function of the Hartmann number for magnetic fields both parallel to and perpendicular to the stream direction. Drag coefficient for the case of the transverse field is about 25% higher than for the case of the longitudinal field. In both cases the drag coefficient increases by a factor of 6 as the Hartmann number increases from 0.0001 to 1.0.

The solution is analogous to that obtained by Chester for flow about a sphere. Authors find, as did Chester, that appropriate solutions can be obtained readily for flows in electrically conducting viscous fluids in the presence of magnetic fields, in contrast to the convergence difficulties which arise in classical Stokes and Oseen motions. H. A. Stine, USA

4273. Lyubarskii, G. Ya., and Polovin, R. V., The disintegration of unstable shock waves in magnetohydrodynamics, *Soviet Phys.-JETP* **9**, 4, 902–906, Oct. 1959. (Translation of *Zh. Eksp. Teor. Fiz., USSR* **36**, 1272–1278, Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Magnetohydrodynamic shock is known to be unstable if the magnetic field is normal to the shock and its strength lies within the region $c_2\sqrt{4\pi\rho_2} < H_x < 4c_2\sqrt{4\pi\rho_2}$, [title source **38**, 8, p. 507, 1959], where c_2 and ρ_2 are the acoustic speed and the density of the flow upstream of the shock. The present paper is an extension of the previous work and deals with the disintegration of such an unstable shock where the magnetic field has only a weak component tangential to the plane of the shock.

A first-order approximation with respect to the weak tangential component of the magnetic field was carried out. The result shows that the initial shock wave splits, in addition to a contact surface, into four discontinuities: a fast and a slow magnetoacoustic shock traveling downstream, an Alfven discontinuity, and a fast magnetoacoustic shock traveling upstream. The distances between these discontinuities grow continuously in time. The

process of disintegration of the initial shock is accompanied by an increase in entropy. Following these arguments, the discontinuities formed from the disintegration of the initial shock are shown to be stable. C. T. Chang, Sweden

4274. Belokon', V. A., The permanent structure of shock waves with Joule dissipation, *Soviet Phys.-JETP* **9**, 4, 932–933 (Letters to the Editor), Oct. 1959. (Translation from *Zh. Eksp. Teor. Fiz., USSR* **36**, 1316–1317, Apr. 1959 by Amer. Inst. Phys., Inc., New York, N.Y.)

If the dominating dissipating mechanism in a magnetohydrodynamic shock is that due to electrical conductivity, and if the shock strength is such that with respect to a coordinate frame fixed to the shock the flow is supersonic upstream and subsonic downstream with respect to the local acoustic speeds of sound, the paper shows that the shock consists of a relatively thick zone through which all flow parameters and the magnetic field strength change continuously and is followed by a discontinuity surface through which no change in entropy and the magnetic field strength occur, but the rest of the flow parameters change abruptly. Following the analogous case discussed by Landau and Lifshitz for an isothermal discontinuity in an ordinary shock, (Fluid Mechanics; Pergamon Press, 1959), such a discontinuity is called an isentropic discontinuity by the author, or preferably, an isentropic-isomagnetic discontinuity. C. T. Chang, Sweden

4275. Kogan, M. N., Shock waves in magneto-gasdynamics, *Appl. Math. Mecb. (Prikl. Mat. Mekb.)* **23**, 3, 784–792, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York, N. Y.)

Two-dimensional shock-wave problems are considered in an ideal gas with infinite electrical conductivity. The nature of changes in flow parameters behind the shock wave is investigated as to their dependence upon the Mach number and magnetic pressure number ahead of the shock and the angular deflection of the flow. In view of the complexity of the relations, only special characteristic points of the shock polar are given and certain degenerate regimes. There are a number of interesting properties which have no analog in ordinary gas dynamics.

D. C. Leigh, USA

4276. Cabannes, H., Dynamics of ionized gases: Determination of stationary shocks attached to a corner (in French), ONERA Pub. 71, 3–9, July/Aug. 1959.

First the conservation equations for plane discontinuities (shocks) in a perfectly conducting compressible fluid are derived, following de Hoffmann and Teller [*Phys. Rev.* **80**, 692–703, 1950] and Lüst [*Z. Naturförscbung* **8a**, 277–284, 1953]. Three special cases are identified: (a) upstream magnetic field normal to shock front, (b) upstream magnetic field parallel to shock front, (c) steady flow with electric field equal to zero. The last-mentioned is the case in which the velocity and magnetic vectors are parallel. This case is treated in detail, and results are presented in a series of graphs. An interesting phenomenon is the appearance, in the results, of shock angles greater than 90° for flow-deflection angles between 0° and 90°. These could be "forward-facing" shocks or shocks attached to an exterior corner (resembling the forbidden expansion shocks of conventional gasdynamics, but here being actually compression shocks). The present investigation, however, does not distinguish between these possibilities, and its author decides to omit all obtuse shock angles in plotting his final results. He expresses doubt concerning the physical reality of forward-facing shocks. It may be advisable to mention here that all shocks which violate the Second Law have been eliminated in the analysis. A general conclusion is reached that the presence of a magnetic field increases the drag (pressure rise) and decreases the temperature rise.

Finally it is argued that it is always possible to solve a steady-flow case where the electric field is different from zero by translating the coordinate system and reducing the problem to the case treated previously.

The reviewer notes that related investigations not referred to by this author include the following: H. L. Helfer, *Astrophys. J.* **117**, 177–199, 1953; J. Bazer and W. B. Ericson, *Astrophys. J.* **129**, 758–785, 1959; K. O. Friedrichs and H. Kranzer, New York Univ. Rept. NYU 6486, 1954 (Reissued July 1958).

W. R. Sears, USA

4277. Bush, W. B., Compressible flat-plate boundary-layer flow with an applied magnetic field, *J. Aero/Space Sci.* **27**, 1, 49–58, Jan. 1960.

The laminar boundary-layer equations are formulated and solved for a flat plate in high-speed compressible air flow where equilibrium dissociation and ionization are assumed and where there is an applied magnetic field having its component normal to the plate proportional to $1/(x)^{1/2}$. The skin-friction and heat-transfer characteristics are determined for free-stream velocities of up to about 1 Weber/(meter)^2.

The results show that the skin friction and heat transfer at a given free-stream velocity decrease with increasing magnetic field strength, and the percentage reduction is constant along the length of the plate. They also exhibit the same hysteresis behavior as was first found in the case of magnetoaerodynamic Couette flow; however, for the flat plate the hysteresis effect disappears at a higher Mach number. Furthermore, it was found that the reduction in heat transfer with increasing field strength is opposite in behavior from that for Couette flow.

From author's summary by S. Eskinazi, USA

4278. Velikhov, E. P., Stability of an ideally conducting liquid flowing between cylinders rotating in a magnetic field, *Soviet Phys.-JETP* **9**, 5, 995–998, Nov. 1959. (Translation of *Zh. Eksp. Teor. Fiz., USSR* **36**, 1398–1404, May 1959 by Amer. Inst. Phys., Inc., New York, N. Y.).

Author considers stability to infinitesimal disturbances of Couette flow of liquid with infinite electrical conductivity σ, for the cases of axial and toroidal magnetic fields. Sufficient but not necessary conditions for stability are derived since the viscosity is neglected in the perturbed flow equations. Problem is related to one treated by Chandrasekhar [AMR **6** (1953), Rev. 3116], who assumed small σ but nonvanishing viscosity.

Magnetic fields are shown to increase flow stability. Major part of analysis deals with cylinders of small spacing which rotate in same direction, but other situations are considered briefly.

A. L. Loeffler, Jr., USA

4279. Dricot, G., and Ledoux, P., Note on the theory of the vibration of an incompressible fluid in the presence of a magnetic field (in French), *Bull. Soc. Roy. Sci. Liege* **28**, 5/6, 115–121, May/June 1959.

Oscillations of an incompressible continuous mass, under the influence of gravity and a superimposed magnetic field, are considered. It is proved that, contrary to other previously published results, even in case of a very strong magnetic field neglecting perturbations of the gravitational field, the approximate square of the frequency of oscillations is composed of two terms: one usually predominant due to gravity and a smaller term depending on the magnetic field intensity. The paper is mainly of interest to astrophysicists.

W. Fiszdon, Poland

4280. Raizer, Yu. P., A simple method of calculating the degree of ionization and thermodynamic functions of a multiply-ionized ideal gas, *Soviet Phys.-JETP* **9**, 5, 1124–1125 (Letters to the editor), Nov. 1959. (Translation from *Zh. Eksp. Teor. Fiz., USSR* **36**, 1583–1585, May 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Reviewer believes this to be an interesting *tour de force* with useful engineering application for quick, rough estimates of composition of very high temperature gases essentially devoid of molecular species. Author replaces the usual set of nonlinear algebraic mass-action equations (Saha equations) with a single integro-differential equation by treating the discrete ionization potentials I_n and number densities N_n of the n-multiply ionized atoms as continuous functions of the index n. To simplify solution of this equation he observes that most of the ions will be of one kind so that $N(n)$ has a peak. By assumption, he then puts the mean ionic charge $\bar{n}$ equal to the value of n at the peak, and further chooses the mean ionization potential to be the value at $\bar{n} + \frac{1}{2}$ (see below). The result is a simple transcendental equation which can readily be solved iteratively for $\bar{n}$.

Author compares his results with accurate values computed previously for air over the temperature range 30,000 K to 100,000 K and for densities from 1 to 10^{-3} times normal. In view of the severity of the approximations used (not exhaustively listed here) the agreement is surprising—even considering that the choice of the mean ionization potential as $I\left(\bar{n} + \frac{1}{2}\right)$ was made to fit the correct data. It seems doubtful that such agreement can be expected in the general case; nevertheless, with suitable modifications the method may be attractive, for example, for the rapid approximate solution of certain magnetogasdynamic problems in which the degree of ionization is required and the temperature-density range is well-defined. J. E. McCune, USA

4281. Smetana, F. O., Some further results on heating a supersonic gas stream with a radio frequency discharge, AFOSR TN 59-1127 (Univ. So. Calif. Engng. Center Rep. 56-207), 16 pp., Nov. 1959.

Results of further experiments with RF discharge heating of a supersonic gas stream are reported. Temperature increases of at least 600 F were recorded although the presence of strong electrical fields made it extremely difficult to interpret temperature indications. The action of the ionized gas and the strong field limits the type of materials which may be used for nozzle materials. Qualitative indications of the decay of active species, N-N recombination, wall heating, effect of pressure, nozzle configuration, and electrode configuration were also obtained.

From author's summary

4282. Thiene, P. G., Flexure of a two-dimensional arc under forced convection, AFOSR TN 59-947 (Plasmadyne Corp. T 2TN089-334), 80 pp., Aug. 1959.

An analytical study is made of a two-dimensional arc under influence of a low Mach number cross flow. The arc plasma is assumed to be dilute, quasineutral, at thermal equilibrium and to consist of electrons, ions and neutral particles with fixed properties. The electric conductivity of the gas is approximated as zero for temperatures T below a threshold T_0 and as a linear function of T for $T > T_0$. This localizes the zone of ohmic heating. Author shows that isotherms and equipotentials are orthogonal in regions where the plasma is quasineutral. It is found that the effect of convection is to shift the center of ohmic power density downstream, while the arc curvature tends to steepen the temperature profile at the upstream arc boundary and to flatten the temperature profile at the downstream boundary. A balance of these opposing effects would give an approximate determination of curvature, width and central temperature of the arc for a given convection. Author gives an alternate and more direct approach for obtaining the curvature by invoking the principle of minimum entropy production for irreversible processes. Accordingly, the arc curvature is determined by the condition that the entropy production is stationary for small changes of arc curvature. For narrow arcs the resulting arc flexure shows analogy to the flexure of structural beams. The "flexural rigidity" of the arc is determined and a tentative blow-out criterion is derived.

H. G. Loos, USA

4283. Yankov, V. V., Behavior of a conducting gaseous sphere in a quasi-stationary electromagnetic field, *Soviet Phys.-JETP* **9**, 2, 388-391, Aug. 1959. (Translation of *Zh. Eksp. Teor. Fiz., USSR* **36**, 560-564, Feb. 1959 by Amer. Inst. Phys., Inc., New York, N.Y.).

In principle one method of isolating a hot plasma from the cold walls of its container is by means of radiation pressure due to externally produced electromagnetic fields, the equilibrium configuration being characterized by a balance between the hydrostatic and electrodynamic forces. This paper treats the theory of the stability of this equilibrium state in the case of a homogeneous plasma sphere assumed to be completely ionized, to be a perfect conductor of electricity, and to obey the equation of state of an ideal gas. The electromagnetic field is taken to be quasi-stationary.

In the first problem considered, the electromagnetic field is assumed to be a superposition of plane standing or traveling waves polarized in various directions, this being a valid procedure only when the wavelength is very much greater than the diameter of the plasma sphere. In a second problem, which probably bears on the acceleration of charged particle bunches by traveling waves, an attempt is made to take spatial inhomogeneities of the electromagnetic field into account.

By calculating the energy change of the system consequent upon a small departure from its equilibrium configuration the author is able to enumerate certain possible stable states, and claims that, in spite of the "rather crude phenomenological model used," his results "indicate the basic features of the behaviour of a plasma in quasi-stationary fields."

R. Hide, England

4284. Post, R. F., Ellis, R. E., Ford, F. C., and Rosenbluth, M. N., Stable confinement of a high-temperature plasma, *Phys. Rev. Letters* **4**, 4, 166-170, Feb. 1960.

Stable, long-time confinement of hot plasma in a "magnetic bottle" is the ultimate objective of high-temperature plasma research. Theoretically, there are relatively few plasma-magnetic field configurations which should permit stable confinement. Even these, when experimentally tested, have until now been found to be unstable, forcing re-examination and extension of the theory. Authors report experiments which represent a contrary example, providing evidence for the existence of a stably confined plasma, observed under circumstances where the simplest hydromagnetic theory predicts instability. From authors' summary

Aeroelasticity

(See also Revs. 3902, 4120, 4317)

4285. Ryazanov, E. V., Some exact solutions of the equations of magneto-gas dynamics with internal gravitational forces present and with a zero temperature gradient, *Soviet Phys.-Doklady* **4**, 3, 554-557, Dec. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **126**, 6, 1224-1227, May/June 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

4286. Crimi, P., Flutter analysis of a supersonic ring wing, AFOSR TN 59-685 (Cornell Univ., School Aero. Engng.), 32 pp., June 1959.

The possibility of flutter of a ring wing without central body is investigated. Inextensional deformations are considered. These

lead to two types of modes, viz, (a) modes in which all circular cross sections are deformed identically and (b) modes in which the deformation of these cross sections is proportional to the axial coordinate. The nth order modes of both types contain $2n$ nodes along the circle.

The aerodynamic forces are derived from piston theory, which restricts the analysis to cases where

$$M \gg 1 \quad \text{and} \quad \frac{r_0\sqrt{M^2-1}}{2l} \gg 1,$$

M being Mach number, r_0 radius, and $2l$ length of the ring wing.

The flutter equations show that no coupling exists between modes of different order, but that, in general, modes of types (a) and (b) of the same order are coupled. These equations are solved for a representative airfoil section. Results show that flutter Mach number is large and increases with n.

A. I. van de Vooren, Holland

4287. Dat, R., Measurements of unsteady aerodynamic coefficients and flutter tests in models (in French), *Rech. Aéro.* no. 62, 45-56, Jan.-Feb. 1958.

Author itemizes some general considerations for test preparation and performance at both subsonic and supersonic flow. The results are derived generally from a careful study of the flutter equations. Topics include: measurement of the elastic constants, masses, and aerodynamic forces; wind-tunnel tests; flutter tests; and model design.

A. H. Hausrath, USA

4288. Salaun, P., Influence of internal damping on the critical speed of flutter (in French), *Rech. Aéro.* no. 61, 19-25, Nov.-Dec. 1957.

Author considers a system with two degrees of freedom, in which the coupling coefficient between the two modes of vibration that are different from zero are only the elastic ones, or the elastic and inertial ones. Author shows in both the cases that increasing the damping coefficient relative to one of the modes can bring a relative instability to the other, and studies the conditions in which this phenomenon occurs. He applies the results obtained to an aeroelastic system consisting of a wing, and calculates for two cases the decreasing of critical speed corresponding to an introduction of a coefficient of internal damping.

C. Ferrari, Italy

4289. Silveira, M. A., and Brooks, G. W., Dynamic-model investigation of the damping of flapwise bending modes of two-blade rotors in hovering and a comparison with quasi-static and unsteady aerodynamic theories, NASA TN D-175, 30 pp., Dec. 1959.

Paper describes test results on the flapwise damping of the second and third symmetric vibration modes of a two-blade model helicopter rotor. Tests were made for the hovering condition with blade angle set at 0 and 3 degrees. The blades were forced to oscillate at their natural frequencies, while in rotation, by means of an external electronic vibrator, coupled to the blades at the hub. The damping was determined from decay records of the vibrations obtained after the vibrator was turned off.

Comparisons are made with the two-dimensional theory of Loewy [*J. Aero. Sci.* **24**, no. 2, Feb. 1957] which takes into account the vorticity shed from the blades during previous revolutions, and which shows that the aerodynamic damping should be very low when the vibration-to-rotation frequency has certain integral numbers. Results of the tests show that the blade aerodynamic damping varies from near zero at slightly below even-integral values of ω/Ω (vibration-to-rotation frequency) to near values predicted from quasi-steady aerodynamics for odd-integral values of ω/Ω. The value of the experimental damping tends to approach that predicted for the two-dimensional wing [Theodorsen, NACA TR 496] when the rotor inflow is increased. In general, good agreement is obtained with Loewy's theory when allowance is made for slipstream rotation.

A. A. Regier, USA

4290. Yates, J. E., and Zeijdel, E. F. E., Flutter of curved panels, AFOSR TR 59-163 (Midwest Res. Inst.), 38 pp., Sept. 1959.

Paper considers pin-edged panels with cylindrical curvature in the stream direction only and neglects static aerodynamic effects. Shallow-shell theory is used with derivatives of displacement in the axial direction neglected in determining radial and circumferential equilibrium. Edge conditions on the latter displacements are satisfied, but assumed sine-modes are not orthogonal. This is in contrast with Reissner's shallow-shell vibration theory in which exact equilibrium is satisfied but the tangential displacements do not satisfy pin-edged conditions. Comparisons to evaluate the significance of these differences are not available.

Quasi-steady air forces are used in the flutter solution, with only the first spanwise mode and either two or three chordwise modes. Numerical results show that the effect of slight streamwise curvature is destablising. Results for larger curvature are unconvincing due to the minimal number of chordwise modes considered and the fact that higher spanwise modes are not investigated.

H. M. Voss, USA

4291. Armstrong, E. K., and Stevenson, R. E., Some practical aspects of compressor blade vibration, *J. Roy. Aero. Soc.* **64**, 591, 117-130, Mar. 1960.

4292. Loiseau, H., Flutter tests in free air on launched models (in French), ONERA Pub. 70, 47-55, May/June 1959.

Paper is a brief note presenting flight test results which supplement earlier studies on flutter. A series of free-flight models of wings with ailerons are air-launched from an airplane and flutter speeds observed. Good agreement is noted between these results and those obtained in wind tunnels and by calculation.

M. J. Thompson, USA

4293. Rainey, A. G., and Byrdsong, T. A., An examination of methods of buffeting analysis based on experiments with wings of varying stiffness, NASA TN D-3, 28 pp., Aug. 1959.

An examination of the validity of some of the assumptions used in the analysis of buffeting loads has been made by means of wind-tunnel tests of models differing in stiffness. A linear analysis predicts buffeting loads which are high by about 25%. This difference may be associated with a relieving effect which causes flexible wings to generate smaller buffeting forces than a more rigid wing. A prediction based on aerodynamic damping only, which apparently contained compensating inaccuracies, provided values of buffeting loads which were closer to the measured values than those predicted by the more complete analysis including both structural and aerodynamic damping.

From authors' summary by S. B. Berndt, Sweden

4294. Mansfield, E. H., The influence of aerodynamic heating on the flexural rigidity of a thin wing, Aero. Res. Counc. Lond. Rep. Mem. 3115, 27 pp., 1959.

Author considers a long solid wing with chordwise thickness variation and chordwise variation of middle-surface stresses, bent into the form of a "near cylinder" of radius R, and derives the differential equation for the chordwise deflection of the wing by variational method.

Where the radius R is small and a large-deflection theory must be used, it is not generally possible to obtain solutions for the chordwise deflection in terms of known function. An exception is the case of a solid wing of constant thickness with a parabolic chordwise variation of strain. Where radius R is large such that a

small-deflection theory can be used, closed solutions can be easily obtained. Author shows that for chordwise variations of strain typical of aerodynamic heating problem, the middle surface stresses will form a resultant moment because of the chordwise deflection. This moment is acting in the same sense as the applied moment, and hence it results in an effective reduction of the flexural rigidity. In several examples, author shows that the loss of flexural rigidity due to aerodynamic heating is comparable to the corresponding loss of torsional rigidity.

Author also determines approximate bounds for the validity of the small-deflection theory and presents a discussion of the end effects in a wing of finite aspect ratio. He also makes an extension of the analysis for the solid wings to built-up wings.

T. H. H. Pian, USA

Aeronautics

(See also Revs. 3829, 3830, 3926, 4111, 4120, 4122, 4123, 4126, 4140, 4261, 4262, 4271, 4292, 4378)

4295. Assadourian, A., and Mallick, D. L., A flight investigation of an acceleration restrictor, NASA TN D-241, 29 pp., Apr. 1960.

The restrictor worked by locking the elevator with the use of a magnetic brake and gear train whenever a function of normal acceleration, pitching acceleration, and pitching velocity exceeded a certain preset value. The tests consisted of pullup maneuvers made at various rates of control input and the results showed that the ratio of peak-to-preset acceleration for optimum brake signal gains increased from values of about 1.2 at the lower elevator rates to about 1.6 at elevator rates of 28° per sec. It is believed possible to limit the ratio of peak-to-preset acceleration to values less than 1.2 for a wide range of elevator rates by the proper choice of signal gains, by keeping structural flexibility to a minimum, and by designing a brake with a time lag in the order of 0.025 second. From authors' summary

4296. Kolnick, J. J., and Rind, E., Investigation of the characteristics of an acceleration-type take-off indicator in a large jet airplane, NASA Memo 4-21-59L, 20 pp., May 1959.

4297. Greenwood, G. H., The effect of fuselage modifications on the zero-lift transonic drag of a fighter aircraft (Hunter F.Mk.1) as measured by free-flight model tests, Aero. Res. Counc. Lond. Curr. Pap. 482, 18 pp., 1960.

4298. Miele, A., and Cappellari, J. O., Jr., Approximate solutions to optimum flight trajectories for a turbojet-powered aircraft, NASA TN D-152, 33 pp., Sept. 1959.

This report presents an approximate "formal" solution by the method of the calculus of variations to an overly simplified aircraft performance problem without leading to any significant new results. Application of the proposed approach to realistic design problems appears to be highly questionable.

C. C. Wan, USA

4299. Wieland, G., Experimental investigations of the power transmission system of short take-off and landing airplanes (in German), *Z. Flugwiss.* **7**, 5, 134-141, May 1959.

Paper describes mechanical performance of power systems of certain early two- and four-propeller airplanes built at the Dornier factory. In most airplanes, engines were remote from propellers, and power was delivered by extension shafts. Several power plant and transmission configurations are described, including tandem and side-by-side arrangements with cross-shafts. Propeller planes in several airplanes were rotatable about a spanwise axis to provide better take-off characteristics. Relation between power-plant arrangement, transmission system and controlability, particularly at low speeds, is discussed. Methods for uncoupling or isolating engine in event of failure are also discussed.

J. E. Goldberg, USA

4300. Faber, S., Dynamic model investigation of a landing-gear configuration consisting of a single main skid and a nose wheel, NASA TN D-213, 14 pp., Feb. 1960.

Variations in nose-wheel shimmy damping and in nose-wheel skid geometry were investigated to determine their effect on directional stability during the landing ground run. The tests were made by towing the model on a moving-belt runway at a constant belt speed. Nose-wheel steering and forms of shimmy damping other than viscous damping about the strut axis were found to produce stable configurations. From author's summary

4301. Gerloff, M., The discus body and its application to V/STOL aircraft and space vehicles, *Aero/Space Engng.* **19**, 1, 51-56, 60, Jan. 1960.

4302. Connor, A. B., and Tapscott, R. J., A flying-qualities study of a small ram-jet helicopter, NASA TN D-186, 22 pp., Apr. 1960.

Flight tests and pilots' opinions extend the range of flying-qualities information to a very small helicopter. The ratios of control power to inertia and of damping to inertia were higher than those for helicopters studied previously and resulted in generally satisfactory handling qualities.

From authors' summary

Astronautics

(See also Revs. 3820, 3831, 4129, 4131, 4234, 4279)

Book—4303. Kurnosova, L. V., edited by, Artifical earth satellites, Vols. 1 and 2 (Translated from the 1958 Russian publications), New York, Plenum Press, Inc., 1960, 227 pp. $9.50 (2 volumes published as 1.)

Volume 1 contains a summary of the scientific data obtained with the first two Russian artificial earth satellites (AES). Included in the papers are data on cosmic rays, atmospheric density (determined from deceleration and from secular variations of the orbit of AES), motion of AES about the center of mass, optical techniques for observation of AES, use of Doppler effect for determining orbit parameters of AES, electron concentrations as a function of altitude, research on animal flights (e.g., the dog Laika) in AES.

The results obtained with the third Russian AES are contained in volume 2. The following topics are considered in this connection: dynamical effects during the motion of AES, temperature distributions as a function of altitude, influence of AES motion on air, atmospheric density about 100 km, ionic composition of the atmosphere, ionospheric studies, geomagnetic measurements, micrometeorite studies, search for corpuscular streams, soft components of cosmic rays, heavy nuclei of primary cosmic radiation, solar batteries, and an acoustical method for measuring the mechanical properties of meteorites.

The 22 articles are revised texts of reports that were presented at the Fifth Assembly of the Special IGY Committee meeting in Moscow in 1958. The physical appearance of the book is good and the English translation excellent. The scientific work summarized in the two volumes is of high caliber and parallels U. S. efforts with AES. Although most of the original information is by now well known to Western space scientists, the book represents a significant addition to any library as a document on pioneering studies with artificial earth satellites. S. S. Penner, USA

4304. Weber, R. J., and Pauson, W. M., Some thrust and trajectory considerations for lunar landings, NASA TN D-134, 37 pp., Nov. 1959.

Paper studies lunar landing pattern composed of retrorocket change from circumlunar orbit to elliptic lunar orbit to retrorocket change to lunar vertical descent to retrorocket soft landing and limited variations from this pattern. The study examines sensitivities of the thrust-weight ratio and speed change parameters and the significance of timing and position errors. It is shown, for example, that speed change is very critical in the first step whereas thrust alignment is much less important. Related equations are developed in an appendix and illustrative graphs are presented.

Z. Horak, Czechoslovakia

4305. Traenkle, C. A., Optimal programming and control of satellite orbits (in English), *Z. Flugwiss.* **7**, 11, 305-313, Nov. 1959.

Reduction of the take-off weight of satellite vehicles can be attained by appropriate launch programs, especially by tangential ascent combined with skin launching. Compared with the conventional launch program, the pay-load may be increased for a given take-off weight by a factor greater than two for extreme cases. The descent mechanics are studied, including the design of optimal programs and the analysis of proximity and skim orbits.

From author's summary by A. N. Petroff, USA

4306. Yegorov, V. A., Some dynamical problems of lunar flight (in Russian), *Uspekhi Fiz. Nauk* **63**, 1a, 73-117, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8367.

The two-dimensional problem of a flight to the Moon is investigated. The analytical treatment of the problem uses the Jacobi integral and the concept of the "sphere of action" of the Moon, outside which lunar interference, and inside which terrestrial interference, are neglected. An electronic computer has been used for the numerical integrations required to compute about a thousand trajectories. A study of the least initial velocities necessary to reach the Moon reveals that the Moon can only be reached with such initial velocities after repeatedly orbiting the Earth. The concept of an "approach trajectory" is introduced, commencing near the Earth and in the first orbit entering the sphere of action of the Moon. The following approach trajectories have been classified by the magnitude and direction of their initial velocities: orbital (passing round the Moon), approximating (not passing round the Moon), impacting, and deviating. The trajectories of the last class, having initial velocities below parabolic, tend to infinity, by the action of the Moon. Within each of these classes, trajectories can be further subdivided according to different characteristics: e.g., incident on the ascending or descending branch; orbiting with a flat return to Earth, etc. Periodic orbiting trajectories exist, but are unstable. The influence of scattering of the initial data is given special consideration.

The following conclusions are reached: the high degree of accuracy required for the initial data implies that to obtain a close orbit round the Moon, particularly for a flat return to Earth, intermediate correction of the trajectory is essential. For trajectories of direct collision and wide orbiting of the Moon, the requirements in regard to accuracy of the starting values are quite reasonable; consequently, flight along such trajectories is possible without applying in flight corrections provided the rocket can be given an initial velocity of parabolic order.

Other problems examined include that of the impossibility of interception by the Moon of a projectile (missile) fired from the Earth, etc. The possibility of applying the same method to the study of flight to the outer planets of the solar system is also indicated and discussed.

V. V. Beletskii

Courtesy Referativnyi Zhurnal, USSR

4307. Nonweiler, T. R. F., Problems of interplanetary navigation and atmospheric re-entry, *J. Roy. Aero. Soc.* **64**, 591, 155-160, Mar. 1960.

Article is a survey of some of the problems of the aerodynamics of re-entry as they affect either purely earth-bound or space vehicles; and in particular, as they are affected by the trajectory the vehicles are designed to follow, or may find themselves upon due to some error of navigation.

From author's summary

4308. Boksenbom, A. S., Graphical trajectory analysis, NASA TN D-64, 46 pp., Dec. 1959.

All the problems referring to the transfer of orbits in plane and space, maximum impulses, longitude reckonings, orbit intersections, etc., have been studied graphically and in a simplified way by means of a notable combination of variables expressed by $X = bV_H/Gm \quad Y = bV_R/GM$ where: V_H is velocity component normal to radial direction, b magnitude of angular momentum, G gravitational constant, M mass of central body, V_R velocity component in radial direction.

The advantage of using the Cartesian system XY is that the orbit eccentricities e are circumferences with centers $X = 0$ $Y = 1$ and radius e, while the lines of $\varphi = \text{cte}$ (φ, true anomaly) have the same center as point of interseccion. The lines bV/GM *and* γ (V velocity, γ path angle) make up a similar system, having its center $X = 0$ $Y = 0$.

As the graphs are made up by straight lines and circumferences, all the problems mentioned may be resolved by means of a ruler and protractor. The curves $G^2M/b^3\,(t - t_p) = \text{cte}$ (t_p, time of perigee crossing) are also included and are symmetrical with respect to the X axis; they resolve all the problems where time is included.

F. R. Marsicano, Argentina

4309. Henry, I. G., Range and accuracy of long-range ballistic missiles, *J. Brit. Interplanetary Soc.* **17**, 3/4, 88-92, May/June/July/Aug. 1959.

Elliptic trajectories of ballistic missiles in vacuum are analyzed, and range angle is expressed as a function of elevation angle and launching speed. Optimum elevation angle for maximum range is found; the apex height is expressed in terms of elevation angle. Expansion of range function yields the relation between the range error and the launching errors in speed and elevation angle. Typical numerical values of error are computed. Dimensionless range curves for different launching speeds are plotted versus elevation angle and may be useful for range computation.

Reviewer believes time curves are also helpful especially for the computation of errors due to Earth rotation. The paper provides necessary data for approximate computation of a ballistic trajectory on spherical Earth. Effects of oblateness and powered trajectory are not included.

P. Bielkowicz, USA

4310. Eggers, A. J., Jr., Allen, H. J., and Neice, S. E., A comparative analysis of the performance of long-range hypervelocity vehicles, NACA Rep. 1382, 20 pp., 1958.

See AMR **12** (1959), Rev. 1581.

4311. Schechter, H. B., Some weight considerations for manned lunar missions, *ARS J.* **30**, 2, 195-197 (Tech. Notes), Feb. 1960.

The total weight requirements for three possible types of manned, round trip, soft landing lunar missions are investigated, all starting out from a space station circling Earth at an altitude of about 350 miles. The first and second missions follow direct hit flight trajectories and employ chemical and nuclear powerplants, respectively. Thrust magnitudes needed are determined by imposing an initial landing deceleration load factor of 3 Earth g. The third mission makes use of a nuclear powerplant as a sort of "ferry boat" to reach a circular orbit around the moon, whereas for the landing and ascent portions at the moon, the final payload is

propelled by chemical rockets. After rendezvous with and attachment to the orbiting ferry boat, the payload is returned to the Earth space station. From author's summary

4312. Sandorff, P. E., Principles of design of dynamically similar models for large propellant tanks, NASA TN D-99, 30 pp., Jan. 1960.

Physical variables entering the problem of liquid propellant motion (sloshing) and its dynamic effects on the container are listed. The nondimensional groups obtained by conventional dimensional analysis are examined and the possibility of construction of dynamically similar models is discussed. It is shown that it is impossible to achieve Reynolds similarity in a reduced scale model. The use of various materials for the models of the structure and the propellant is discussed, but with no experience of an actual model construction yet available the conclusions are only indicative of the possibilities.

O. C. Zienkiewicz, USA

4313. Turner, K. L., Shaw, D. S., and Enderson, L. W., Jr., Static stability and separation characteristics of a two-stage rocket configuration at Mach numbers from 1.57 to 4.50, NASA TN D-188, 35 pp., Jan. 1960.

The subject investigation was conducted in the Langley Unitary Plan wind tunnel. Each stage of the two-stage rocket configuration is a body of revolution with a length-diameter ratio of approximately 8. Model configurations tested include each stage separately and combined, and the stages being systematically separated from each other. This paper contains axial force, static stability, and separation characteristics at Mach numbers from 1.57 to 4.50 and Reynolds numbers per foot from 1.5×10^6 to 4.0×10^6. From authors' summary

4314. Leon, H. I., Spin dynamics of a thrusting rocket in vacuum, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 1959, 514-530.

Paper presents small-angle-of-attack analysis for a rocket with thrust applied. Solutions are given for cases of thrust malalignment with small mass change and for ideal thrust with large mass change. The former shows exact correspondence with a non-powered body with products of inertia. Small angle of thrust or that of principal axis of inertia affect angle of attack identically. The second case shows jet damping effect for a constant ratio of moments of inertia. Spiral convergence of angle of attack due to jet damping is described analytically; spinning and non-spinning rockets are compared. Solutions are given in terms of Euler angles, and in form permitting physical interpretation.

P. Bielkowicz, USA

Symposium on the exploration of space, *J. Geophys. Res.* **64,** 11, Nov. 1959.
(Revs. 4315-4330)

4315. Jastrow, R., Introductory remarks, 1647-1651.

4316. Whipple, F. L., Solid particles in the solar system, 1653-1664.

4317. Gold, T., Plasma and magnetic fields in the solar system, 1665-1674.

4318. Parker, E., Extension of the solar corona into interplanetary space, 1675-1681.

4319. Van Allen, J. A., The geomagnetically trapped corpuscular radiation, 1683-1689.

4320. Simpson, J. A., (Chairman) Round-table discussion, 1691-1693.

4321. Newell, H. E., Capabilities for space research, 1695-1712.

4322. Kuiper, G. P., The moon, 1713-1719.

4323. Urey, H. C., Primary and secondary objects, 1721-1737.

4324. de Vaucouleurs, G., Remarks on Mars and Venus, 1739-1744.

4325. Rossi, B., (Chairman) Round-table discussion, 1745-1750.

4326. Friedman, H., Rocket astronomy, 1751-1763.

4327. Goldberg, L., Astronomy from satellites and space vehicles, 1765-1778.

4328. Townsend, J. W., Jr., Experimental research program in the space sciences, 1779-1787.

4329. Jastrow, R., Outer atmospheres of the earth and planets, 1789-1798.

4330. Spitzer, L., Jr., (Chairman) Round-table discussion, 1799-1800.

End of Symposium

Ballistics, Explosions

(See Revs. 4133, 4248, 4251, 4261, 4262)

Acoustics

(See also Revs. 4065, 4066, 4214)

4331. Ageeva, N. S., Propagation of an acoustic pulse in an underwater sound channel, *Soviet Phys.—Acoustics* **5,** 2, 147-151, Nov. 1959. (Translation of *Akust. Zh., USSR* **5,** 2, 146-150, Apr./June 1959 by Amer. Inst. Phys., New York, N. Y.)

An analysis of signal form in connection with the propagation of an acoustic pulse in an underwater sound channel is made by comparing the record of the signal with a ray diagram corresponding to the experimental conditions. From author's summary

4332. Gottlieb, P., Sound transmission through a velocity discontinuity, *J. Acoust. Soc. Amer.* **31,** 7, 1036-1037 (Letters to the editor), July 1959.

The attenuation of a sound wave in a steady flow, with the flow gradient normal to the flow lines, is approximated by three different methods. The first method approximates the steady flow by layers of constant velocity and applies the boundary conditions of Rittner at each interface. The second method uses the analytic solution for the continuous flow. The last method is similar to the first but uses the boundary conditions of earlier authors. It is found that the first and second methods give the same answer, and this answer disagrees with that obtained by the third method.

From author's summary by R. E. Goode, USA

4333. Walker, C. T., and Adams, C. E., Thermal effects of acoustic streaming near a cylindrical obstacle, *J. Acoust. Soc. Amer.* **31,** 6, 813-814 (Letters to the editor), June 1959.

The cooling effect of acoustic streaming on a heated thermistor

imbedded in a cylinder placed in a sound field in air was studied and found to be in accord with theory.

From authors' summary by D. W. Dunn, Canada

4334. Brekhovskikh, L. M., Surface waves in acoustics, *Soviet Phys.—Acoustics* **5,** 1, 3–12, Aug. 1959. (Translation of *Akust. Zh., USSR* **5,** 1, 4–14, Jan./Mar. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The surface waves treated by the author are analogous to the linearized subsonic flows over a wavy wall discussed in aerodynamic theory. The pressure and velocity variations decay exponentially with distance from the surface. Author shows analytically how such disturbances can be generated by a sound source on a plane or cylindrical surface whose acoustic impedance is purely imaginary, and demonstrates that the propagation speed is less than the sound speed in the medium. If the excited surface has discontinuous properties in the direction of motion, then the surface waves produce a radiation field whose principal lobe geometry is related to the length of the radiator.

A. Kistler, USA

4335. Wehrmann, O., Acoustic excitation of turbulence in the free jet (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 102–108.

Experiments in the boundary layer of a free jet behind a nozzle, at Reynolds numbers up to 20,000, are discussed. The possibility of influencing the conditions of flow acoustically was realized during measurements employing the hot-wire method, primarily without artificial disturbances. The ring vortices which, forming downstream behind the nozzle, initiate the state of perfect turbulence when dissolving later, can be assessed, in accordance with the hot-wire method, by four characteristic properties:

1. measuring the field of mean velocities (measurement of $\bar{c}$);
2. taking the curve of exitation and the strength Γ of the ring vortices (measurement of $\hat{c}$ and c_{φ} respectively);
3. finding the relation between the frequency of the ring vortices and the velocity of the flow (frequency theorem);
4. finding the distance between two ring vortices (measurement of the wave length λ).

In order to be able to study the stability of the free jet and, in particular, the free boundary layer as it governs the effects behind the nozzle exit, the acoustic effect was chosen as the means for artificial disturbance from a loud-speaker arranged externally to the field of flow. The following results were obtained:

(a) The separation of the vortices can be influenced by the energy of sound, superimposed to the boundary layer. At a constant velocity of flow the so-called "natural frequency" of the vortices can be "carried away" over a certain region. The results show a trend similar to that of the well-known stability curves for the boundary layer over a flat plate as given by Tollmien, Schichting and Lin.

(b) The strength Γ of the ring vortices close behind the nozzle exit can be considerably increased by acoustic influence. As the position of the lines of mean velocities $\bar{c}$ is given by the exchange of momentum of the ring vortices, a considerable change of the entire field of flow is obtained.

(c) Applying a feedback coupling, a curve can be found for the maximum frequency of exitation by feeding the amplified hot-wire signals first back into a loud-speaker from which the signals are then reproduced.

(d) The speed of vortex transportation u_p as affected by acoustics can be found from measuring phase and frequency. At a constant velocity of flow the wavelength is shown to remain constant, whereas the velocity of vortex transportation changes.

From author's summary

4336. Lothe, J., Acoustic radiation force on a uniformly moving smooth body, to the first order in the velocity, *J. Acoust. Soc. Amer.* **32,** 1, 140–141 (Letters to the editor), Jan. 1960.

It is shown that the acoustic radiation force on a uniformly moving smooth body is given correctly to the third order by simple first-order theory, in agreement with a calculation by Nabarro. [Phil. Mag. **41,** p. 1276, 1950; AMR **4** (1951), Rev. 2601].

From author's summary

4337. Fitzpatrick, H. M., and Strasberg, M., Hydrodynamic sources of sound, David W. Taylor Mod. Basin Rep. 1269, 43 pp., Jan. 1959.

Structures entering or in fluids generate noise by two mechanisms: structural vibrations and hydrodynamical effects. This paper provides an excellent summary of the hydrodynamical effects and, in the reviewer's opinion, should be required reading for all engineers concerned with hydrodynamical noise. An extensive bibliography and critical comment by leading researchers in the field is included. Four sources of hydrodynamical noise are discussed: entrained air bubbles; vaporous cavitation; surface disturbances; and unsteady flow. For each of these the physical phenomena involved in noise generation, the available experimental data, theoretical methods of analysis, and the relations between the flow parameters and the amplitude and spectral distribution of the sound are discussed.

M. S. Weinstein, USA

4338. Dyer, I., Franken, P. A., and Ungar, E. E., Noise environments of flight vehicles, *Noise Control* **6,** 1, 31–40, 51, Jan./Feb. 1960.

Knowledge of noise environments of rockets and ramjets is important in structural design calculations. Authors discuss various noise sources associated with flight vehicles but do not deal with structural effects [e.g. Goodman and Rattayya, AMR **13** (1960), page 81]. Amplitude and space-time correlations are given for noise due to turbulent exhaust stream of motor and it is shown that noise from turbulent flow in wake of vehicle is qualitatively similar except that most intense radiation is directed upstream. In supersonic flight, noise from either of these sources obviously cannot reach vehicle but pressure fluctuations associated with wake turbulence may be felt directly by vehicle base without any intermediate sound radiation. Other noise sources considered to be of practical significance are boundary-layer pressure fluctuations and shock oscillations. Effects of flight through atmospheric turbulence and micro-meteorites appear to be of lesser importance. Combustion instability and engine oscillations are not discussed.

J. K. Kilham, England

4339. Williams, J. G. M., and Stevenson, D. C., The noise field from designed nozzles at different Mach numbers, Aero. Res. Counc. Lond., Curr. Pap. 448, 34 pp., 1959.

Measurements of radiated noise from unheated air jets have been made for a family of 1/2-inch diameter convergent and convergent-divergent nozzles having exit velocities in the range 800–1800 fps. Particular attention was given to the accuracy of the nozzle contours and to minimizing wind effects and reflections during the testing. Free-field radiation patterns, frequency spectra, and total radiated acoustic power were determined for the conventional nozzles and for a special setup which provided for a sheath of low-speed air around the main jet.

Results indicate that the ratio of acoustical power to mechanical power of a jet tends to increase as the jet velocity increases. It was also found that modification of the velocity profile of a jet to reduce its shear gradient is not so effective in reducing the noise produced as is a reduction of the mean velocity.

H. H. Hubbard, USA

4340. Krasil'nikov, V. A., and Khaminov, D. V., Propagation of finite-amplitude ultrasonic waves in a relaxing medium, *Soviet Phys.—Acoustics* **5,** 2, 167–170, Nov. 1959. (Translation of

Akust. Zh., USSR **5**, 2, 166–169, Apr./June 1959 by Amer. Inst. Phys., New York, N. Y.)

The peculiarities of the propagation of waves of finite amplitude (p = 0.1–3.0 atmos) in a relaxing liquid (acetic acid at various concentrations) were experimentally studied at frequencies of 500, 1000 and 2000 kc. It is established that the behavior of a finite-amplitude wave under these conditions is determined, for the most part, by the high coefficient of absorption of the liquid, which impedes the development of the higher harmonics. The values for a number of the quantities obtained are found to be in satisfactory agreement with those calculated according to the equations of approximation theory. For the sake of comparison, data on the propagation of waves in a nonrelaxing liquid—glycerin—are given.

By means of a measurement of the phase difference between the fundamental and second harmonics it proved possible to measure the dispersion in acetic acid. From authors' summary

4341. Rozenberg, L. D., and Sirotyuk, M. G., Apparatus for the generation of focused ultrasound of high intensity, *Soviet Phys.—Acoustics* **5**, 2, 206–210, Nov. 1959. (Translation of *Akust. Zh., USSR* **5**, 2, 206–211, Apr./June 1959 by Amer. Inst. Phys., New York, N. Y.)

An ultrasonic concentrator at whose focus intensities of 60–70 w/cm^2 can be obtained is described, and the results of preliminary testing on it are given. From authors' summary

4342. Polotskii, I. G., Taborov, V. F., and Khodov, Z. L., Apparatus for measuring the velocity of ultrasound in liquid metals, *Soviet Phys.—Acoustics* **5**, 2, 202–205, Nov. 1959. (Translation of *Akust. Zh., USSR* **5**, 2, 202–205, Apr./June 1959 by Amer. Inst. Phys., New York, N. Y.)

An ultrasonic pulse apparatus for determining the velocity of ultrasound in liquid metals and alloys is described, and the results of a measurement of the velocity of ultrasound in certain liquid metals are cited in the paper.

From authors' summary

4343. Lopatko, I. F., and Usoskin, G. I., A method for thickness measurement by means of an ultrasonic pulse thickness-measuring device, *Indust. Lab.* **24**, 12, 1601–1605, Dec. 1958. (Translation of *Zavod. Lab., USSR* **24**, 12, 1464–1466, Feb. 1960 by Instrument Society of America, Pittsburgh 22, Pa.)

4344. Kuz'menko, V. A., Determination of elastic constants of materials by means of longitudinal ultrasonic vibrations, *Indust. Lab.* **24**, 11, 1536–1537, Nov. 1958. (Translation of *Zavod. Lab., USSR* **24**, 11, 1407–1408, Dec. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

Micromeritics

4345. Rajagopal, E. S., Truncation corrections in particle size analyses (in English), *Kolloid Z.* **164**, 1, 1–3, May 1959.

Under practical conditions, various methods of particle-size analysis suffer from instrumental errors of the truncation type for which no method of correction has been used. Although the general problem of truncated normal distributions has not been solved, the special case involving a known truncation point and a large number of observations has been solved by Fisher and Hald ["Statistical theory with engineering applications"; AMR **5** (1952), Rev. 2981]. Numerical examples using this solution on published data are given and explained. S. R. Faris, USA

4346. Rammler, E., and Kubasch, A., On the applicability of the RRS grain-size net and of the RRS formula to winnowed products (in German), Freiberger Forschungshefte no. A52, 48–65, Sept. 1956.

The Rosin-Rammler-Sperling (RRS) formula is an exponential function which is represented, in a double-logarithmic chart, by a straight line. It has been primarily intended to represent milled goods in general; however, it has been found to fit only fine-milled goods, not coarse-fractured material. Granular materials, obtained by sifting and winnowing through cyclones and hydrocyclones, do not generally follow the RRS formula, inasmuch as the representation in the double-logarithmic graph deviates from the straight line in the large-grain range. Numerous examples of grain-size distributions are shown in graphs, and their RRS-formula parameters determined. Theoretical analysis of the relations is presented. Authors conclude that the representation in the RRS chart of granular material obtained by winnowing is useful for its appraisal, even though the graph deviates from the straight line. K. J. DeJuhasz, USA

4347. Rausch, W., Investigation of drag of grain-like and pulverized solids in air (in German), *Ing.-Arch.* **26**, 5, 319–332, Oct. 1958.

Author describes a method for determining the drag of mixtures of fine particles suspended in a gas stream. Particles are accelerated, essentially from rest, through a long throat nozzle by an airstream. The pressure loss in the airstream due to accelerating the particles is measured and used to calculate the drag of the mixture. Results are reported by stating the equivalent mean diameter of the mixture of spherical particles which would have the same resistance as the actual mixture if there were no interactions between particles. The method is confirmed by showing that extrapolation of the experimental results to zero solids loading gives an equivalent spherical diameter nearly equal to the actual mean diameter of the mixture.

Tests on glass beads and catalyst particles are reported. In both cases the equivalent spherical diameter of the mixture increased as the solids loading increased. For the catalyst, a dependence on air velocity was also shown.

C. L. Coldren, USA

4348. Kogan, Ia. I., Pfeifer, T. A., and Korsakov, V. V., An aerosol sedimentation method for determination of the particle-size distribution in powders and dust deposits, *Indust. Lab.* **24**, 10, 1350–1355, Nov. 1959. (Translation of *Zavod. Lab., USSR* **24**, 10, 1219–1223, Oct. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

4349. Grishanin, K. V., The equation of the non-scouring velocity (in Russian), *Trudi Leningrad In-ta Inzh. Vodn. Transp.* no. 24, 27–30, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8765.

The problem concerns the establishment of a rational relationship between the non-scouring velocity U_0 of a flow and the region of flow conditions in which the resistance to the flow is proportional to the square of the velocity. From elementary constructions which do not result from an investigation of the essential nature of the phenomenon but are based on merely general considerations, the author obtains an expression identical in form with one derived by the present reviewer (in 1932), as is duly noted in the paper. In addition to this expression in logarithmic form, author considers likewise acceptable such exponential formulas as those of G. I. Shamov.

Analyzing the experimental data, author determines the constants of the equation, which appears finally as

$$U_0 = 0.75 \sqrt{g\left(\frac{\rho s}{\rho} - 1\right)}\, d \log \frac{15b}{d}$$

where ρs and d are the density and size of the particles, ρ density of the water, b depth of the flow. The limits of applicability of

the suggested formula are not indicated in the paper. It should be noted that the data obtained by V. S. Knoroz, Ckeng-King, and others, indicate that when particles start moving, the lower limit of the square-law region corresponds to values of $d = 1.5$ to 2.0 mm.

I. I. Levi

Courtesy Referativnyi Zhurnal, USSR

4350. Levsh, I. P., and Yerofayeva, O. B., The constrained sedimentation of solid particles in a viscous fluid (in Russian), *Trudî Sredneaz. Politekhn. In-ta* no. 4, 291–298, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8981.

An experimental investigation of the mechanism of constrained precipitation of quartz sand with a grain size of 0.75 to 1.0 mm and glass balls with a diameter of 2.4 mm, in aqueous solutions of glycerine with a viscosity of 1.75 to 155 centipoises. The fundamental relationship investigated was the ratio between the volume concentration of the suspension $(1 - \varepsilon)$ and the Reynolds number R, which is found to be approximately in inverse proportion. It is pointed out that the absolute rate of constrained sedimentation of the smaller particles (sand) is within the limits of volume concentration of the solid phase of 2.25 to 20%, in media with viscosities between 14.5 and 155 cP, practically independent of the volume concentration. A certain relationship to the volume concentration becomes apparent in the free fall of the larger particles (glass balls) under the same conditions. The relationship between the rate of constrained precipitation and the viscosity of the medium is very pronounced. An expression is suggested

$$R = (1 - \varepsilon)^n - A(1 - \varepsilon)$$

wherein $n = 0.25$, $A = 11.0$; expression is applicable for the rate of constrained precipitation in viscous media. The statement of the authors that the rate of constrained precipitation is practically independent of the volume concentration is inaccurate. In the particular experimental conditions, the relationship between the rate of precipitation and the concentration has been masked by the far more pronounced relationship between precipitation and viscosity.

U. Ts. Andres

Courtesy Referativnyi Zhurnal, USSR

4351. Zhulayev, R. Zh., The calculation of the interception of sediments by slotted sand and gravel traps (in Russian), *KazSSR Gylym Akad. Khabarlary* no. 11, 18–33, 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9010.

An investigation of zero-head tunnels (pressure pipes) with entry of the water and the sediments (deposits) through a slit at the bottom of the flow channel. This slot is arranged across the original bed, normal to the primary direction of the flow therein. Similarity considerations are presented, the differential equations of motion are set up, and some experimental results are given. A general form of equation for the interception of sediments by the slot is developed. Certain conclusions and suggestions are put forward:

(1) Any pressure head in the tunnel or pressure pipe is undesirable.

(2) Certain nondimensional similarity parameters are significant for the motion of sediments on the bottom and in the slot.

(3) It is pointed out that an increase in the width of the slot also increases the degree of interception of the sediments, with simultaneous increase in the amount of wasted water. The wastefulness of this process (in the case of shortage of water for overflow and washing) calls for an improvement in the structural designs of the slot; in particular, the provision of an "auxiliary chamber" (in which the sediments are precipitated) and "bottom guiding walls" ('groynes'), for concentrating the region of entrainment of the sediments, and reducing the consumption of wash water.

Methods are stated for the approach to a calculation of the interception of sediments by a slotted structure. The inadequacy of numerical definitions of a number of coefficients and constants considerably hampers the actual calculation of designs for slotted sand and gravel traps.

M. S. Byizgo

Courtesy Referativnyi Zhurnal, USSR

4352. Glukhovsky, D. I., The outflow of a drop-forming liquid from a tapering nozzle (in Russian), *Sb. Nauchn. Trudî Severo-Kavkazsk. Gorno-Metallurg. In-ta* no. 14, 298–306, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8684.

A description of the experimental results obtained with a liquid issuing from a conically-expanding nozzle with a taper $\beta = 5°30'$. The diameter of the inlet to the nozzle, d_1, is 20 mm. The experiments were conducted with a load of 10 – 101 cm, and a nozzle length of 2.8, 4.6, 7.25, 9.0 and 13.0 times the diameter d_1. The experimental conclusions are in brief as follows: (1) A change in head does not generally influence the value of the flow coefficient in the inlet and outlet orifices. (2) The flow coefficient of the inlet increases with the length of the nozzle. (3) The fundamental criterion determining the flow capacity of a conically-tapering (expanding) nozzle is the flow coefficient of the inlet. (4) The values of the flow coefficient given in manuals and textbooks on hydraulic engineering, between 0.75 to 0.50, correspond to a nozzle length averaging $4\,d_1$.

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR

4353. Ponstein, J., Instability of rotating cylindrical jets, *Appl. Scient. Res.* (*A*) **8,** 6, 425–456, 1959.

A mathematical treatment is given of the instability of rotating cylindrical jets under the action of inertia effects of the jet and its surface tension and neglecting the viscosity of the liquid and the inertia of the surrounding air. This is an extension of the classical problem of instability of jets without rotation treated by Rayleigh and Weber. The author has considered three types of jets: the solid jet, the hollow jet and the hollow infinitely thick jet. The criteria for instability are formulated for rotationally symmetric perturbations and, in one case, for nonrotationally symmetric perturbations applying the linear theory of hydrodynamic stability. An important conclusion is that for rotating jets the nonrotationally symmetric perturbations are in some cases more unstable than the rotationally symmetric ones.

Reviewer thinks that the paper should be of interest to engineers working in the field of atomization.

S. D. Nigam, India

4354. Reynolds, W. C., Behavior of liquids in free fall, *J. Aero/Space Sci.* **26,** 12, 847–848 (Readers' Forum), Dec. 1959.

Porous Media

4355. Odeh, A. S., Effect of viscosity ratio on relative permeability, *J. Petroleum Technol.* **11,** 12, 346–353, Dec. 1959.

Author examines the dynamic behavior of two-phase flow in porous media. In a theoretical analysis author assumes the porous medium to consist of straight circular capillaries of different radii. Utilizing Poiseuille's law, and assuming a molecular film of wetting-phase flow to stick to the wall of the capillaries, author obtains equations which explain qualitatively the behavior of two-phase flow. In particular the equations indicate that the relative permeability to non-wetting phase is a function of saturation as well as of the viscosity ratio, the thickness of the molecular film and pore size.

Experimental work was conducted to test the validity of the derived equations. Four core samples were tested with four non-wetting liquids (viscosity ranging from 0.42 to 71.30 cp) and two wetting liquids (viscosity 0.86 and 0.96 cp).

It was found that relative permeability to the non-wetting phase varies with viscosity ratio, increasing with its increase; it reaches a maximum at interstitial saturation of the wetting phase and decreases as the saturation of the non-wetting phase is decreased; the relative magnitude of the viscosity ratio effect varies inversely with pore size, i.e., with the single-phase permeability; at a high single-phase permeability value (over 1 Darcy) the effect of viscosity ratio becomes negligible; the relative permeability to the wetting phase is not affected by viscosity ratio.

G. Noseda, Italy

4356. Drondin, E. F., Ground water seepage into a foundation pit (in Russian), *Gidrotekh. Stroit.* **27**, 8, 45–46, Aug. 1958.

Two charts are given for simplifying numerical determination of seepage into river foundation pit. The pit is supposed to be surrounded by sheet-pile wall which is supported by sand berms and unwatered by open drainage. The charts refer to the solution given by F. B. Nelson-Skorniakov, in *Gidrotekh. Stroit.* **25**, 9, 44–47, Oct 1956. Solution was obtained by splitting the cross section into two parts, which were successively solved by conformal transformation.

Z. J. Bazant, Czechoslovakia

4357. Alexandrian, V. V., The analysis of incomplete pressure wells with water-impermeable side walls and bottom (in Russian), *Trudī Arm. N-i. In-ta Gidrotekhn. i Melior.* no. 2, 95–98, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10124.

An attempt is made to construct an approximation formula for the inflow to a well imperfectly exposing the stratum. A horizontal plane passing through the bottom of the well divides the flow into two parts. The flow toward the side-walls of the well is assumed to be plane-parallel in its upper part, while for the lower part, all the equipotential lines are assumed to be ellipsoids of rotation. This latter assumption is, however, erroneous and applicable only in the absence of an hydraulic resistance. Consequently, the derived approximate formulas correspond to the case of a stratum of infinite depth, and there is no significance in the assumption of an imperfect well, nor in any comparison of the results with the Muskat formula.

V. N. Nikolaevskii

Courtesy Referativnyi Zhurnal, USSR

4358. Kheyirov, Z. B., and Marscinov, G. P., A solution for some problems of unsteady seepage in strata of variable permeability (in Azerb.), Elmi Eserler Azerb. Univ. no. 6, 31–48, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10127.

A solution is suggested for unidimensional problems of unsteady seepage in strata of variable permeability. For a finite stratum with given pressures in the feeding contour and the gallery, and permeabilities varying according to

$$k(x) = (a_1 x + b)^n$$

(a_1, b, n = constants), authors have succeeded in obtaining a rigorous solution for the pressure distribution. The problem is solved by the Fourier method, subsequently applying the Duhamel theorem. The resulting solution is obtained in the form of an infinite series. Several cases with different boundary conditions are examined, for the same rate of variation of the permeability. In conclusion, the problem is solved of determining the pressure distribution for a linear law of change of the permeability in an infinite stratum with a given delivery at the end. The solution in this case is obtained in finite form, using the principle of similarity. It should be noted that, for strata of infinite extent, a solution of the problem can exist only for particular boundary conditions and a given rate of change of the permeability. Several concrete numerical examples are given but are not analysed. There are misprints.

V. Yu. Kim

Courtesy Referativnyi Zhurnal, USSR

4359. Saffronov, S. V., and Allakhverdiyeva, R. A., Experimental investigations on the combined inflow of petroleum and water to an incomplete borehole (in Russian), *Trudī Vses. Neftegaz. N.-i. In-ta* no. 10, 131–140, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10143.

The results of experimental investigations of the combined influx of two inhomogeneous fluids to a borehole with incomplete exposure of the stratum are examined. A scheme is presented for a parabolic model slit, and the essential modelling conditions are stated. The execution of the experiments is described and their results are plotted. It is found that initially, with increasing value of

$$\Delta\overline{P} = \frac{\Delta p}{b\Delta\gamma\cos\beta}$$

(where Δp = depression, b = depth (height) of the slit, β = angle of incidence of the plane of the slit to the vertical, $\Delta\gamma$ = difference of the mass densities), the degree of water flooding of a borehole increases; and the greater the magnitude of the aqueous component at the feeding contour, the greater the percentage of water. Subsequently, this relationship becomes less close and, at particular values of ΔP, practically ceases; the curves become flatter, asymptotically approaching their theoretical (analytical) limits. Thus these experiments give a more accurate definition of the limits of applicability of the formula of M. M. Glogovsky [*Trudī Mosk. Neft. In-ta* no. 11, 1951]; and qualitatively confirm the results of industrial tests on boreholes. Analyzing the curves of the interface between the two fluids, authors arrive at a more rigorous value of the quantity R_0 = radius of the base of the aqueous cone; according to the authors' sreults, $R_0 = 2\text{–}4b$.

I. D. Umrikhin

Courtesy Referativnyi Zhurnal, USSR

4360. Petukhov, A. I., Determination of the rate of water seepage in the dewatering of a carboniferous bed with highly inhomogeneous sizing of the coal particle (in Russian), *Izv. Dnepropetr. Gorn. In-ta* **27**, 113–119, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10149.

Experimental results are presented on the determination of the influence of the screen analysis (presence of a filler) on the filtering capacity of coal particles. A maximum loss of filtering power was observed with 32–34% of fines (filler) in a granulated coal mixture. The rate of filtration (seepage) of water in a coal bed with a fine filler can be determined by the empirical formula

$$v_c = cv_f m_1$$

where m_1 is the skeletal porosity of the coal bed, v_f the rate of seepage in the filler, determined by its coefficient of percolation, and c is an empirical coefficient with a mean value of 1.42 (average of eight samples).

A. R. Shkirich

Courtesy Referativnyi Zhurnal, USSR

4361. Rosenberg, M. D., The radial displacement of gassy petroleum by water (in Russian), *Trudī Vses. Neftegaz. N-i. In-ta* no. 10, 266–295, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10138.

The problem is investigated of the radial displacement of gassy petroleum by water with a constant volume of the influent, or constant pressure on the feeding line. By numerical integration of the systems of nonlinear differential equations obtained for concrete examples, time-relationships are established for the mean pressures, mean saturation, the gas factor, and the position of the water-petroleum interface, which are tabulated and plotted. These results considerably improve the data obtained by the author and M. M. Glogovksy in preceding researches. It is demonstrated that in the case of a constant pressure on the feeding contour, the process of displacement of gassy petroleum by water can be divided into two stages. In the first, relatively brief stage, the

pressure and saturation values fall abruptly, as would be the case in the conditions of a dissolved gas. Then, at the beginning of the second stage, saturation and pressure increase; after which, gassy petroleum is displaced by water practically as an incompressible fluid, which considerably simplifies the calculations.

V. L. Danilov

Courtesy Referativnyi Zhurnal, USSR

4362. Kim, V. Yu., A particular problem in the control of the displacement of an oil-bearing contour (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR Ser. Fiz.-Mat. Tekhn. Nauk* no. 11, 57–61, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10136.

The motion of a homogeneous liquid following a linear law of percolation in a homogeneous horizontal stratum of constant thickness is investigated. The site is bounded by rectilinear faults (two boundaries are mutually parallel, the third perpendicular thereto). A chain of boreholes is developed, the location line of which coincides with the "cross-fault". The problem is solved by the known method of G. S. Salekhov [title source, no. 6, 3–38, 1955]. The case is examined when, at the initial time the oil-bearing contour is represented by a straight-line segment not parallel to the location line of the boreholes. A curve is given for the change in output of the boreholes with time, and the conditions for solvability of the problem are stated.

V. A. Karpyichev

Courtesy Referativnyi Zhurnal, USSR

Book—4363. Istomina, V. S., The seepage resistance of soils (in Russian), Moscow, Gos. Izd-vo Lit. po Str-vu. i Arkhitekt., 1957, 295 pp. 14 r. 80 k.; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10178.

Chapter headings. Existing means of evaluating the seepage resistance of soils. I: Investigation of the seepage deformation of uncompacted soils. II: Absolute pore dimensions of uncompacted soils. III: Seepage disintegration of uncompacted soils; in a rising flow. IV: Seepage disintegration of stabilizing sandy soils in a rising flow; contact overflow. V: Seepage disintegration of stabilizing soils by a longitudinal flow; contact washout. VI: Seepage disintegration of mixed sandy-gravel soils in a rising flow; suffusion. VII: Seepage disintegration of sandy soils by a curvilinear flow. VIII: Permissible flow gradients and velocities in sandy soils. IX: Characteristics of consolidated soils. X: Seepage disintegration of consolidated soils. XI: Drain filters in uncompacted (loose) soils. XIII (sic!): Determination of the seepage stability of foundation soils in the designing of the underground plan of a dam. XIV: Blanketing materials under the revetment of earth-dam slopes.

Courtesy Referativnyi Zhurnal, USSR

4364. Rosenberg, M. D., The displacement of petroleum by gas and water (in Russian), *Trudi Vses. Neftegaz. N.-i. In-ta* no. 10, 141–215, 1957; *Ref. Zh. Mekh.* no. 9, 1958, Rev. 10137.

A very schematic examination of a number of problems relating to the processes of displacement from a porous medium of, on the one hand, petroleum by gas; and, on the other hand, the bilateral displacement of petroleum by water and gas (neglecting the viscosity of the gas and the compressibility of the petroleum; in most cases, the displacement is assumed to be volume for volume, and other different assumptions are made in the individual problems). It is pointed out that in actual fact the processes of displacement are considerably more complicated than is assumed in the overwhelming majority of cases investigated; in this regard, the closing paragraphs of the paper contain corrections to the formulation of the problems; it remains unexplained why the solutions to many of the problems are given without these corrections in the previous sections of the paper

V. A. Arkhangel'skii

Courtesy Referativnyi Zhurnal, USSR

4365. Morgan, P. G., A note on the drag of a screen at low Reynolds number, *J. Phys. Soc. Japan* **14,** 11, p. 1645, Nov. 1959.

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 4105, 4146, 4216, 4268, 4331, 4337)

4366. Takeuchi, H., Press, F., and Kobayashi, N., Rayleigh-wave evidence for the low-velocity zone in the mantle, *Bull. Seismol. Soc. Amer.* **49,** 4, 355–364, Oct. 1959.

Variational calculus methods are applied to the problem of dispersion of mantle Rayleigh waves. Two earth models are used. One is Gutenberg's model with a low-velocity layer around 150-km depth. The other is a Jeffreys-Bullen model (no low-velocity layer) modified above 200-km depth so as to join smoothly to the explosion-determined velocities just under the Mohorovičić discontinuity. Both models give almost identical theoretical dispersion curves which agree well with the Ewing-Press observations of mantle Rayleigh waves for periods longer than 250 sec. This result means that the minimum group velocity at about 250 sec is mainly due to a sharp increase of shear velocity at about 400-km depth, which is a common feature for the two models. For periods shorter than 250 sec, Gutenberg's model gives results concordant with the observations. The modified Jeffreys-Bullen model disagrees significantly with the observations. This demonstrates the existence of a low-velocity layer in the upper mantle.

From authors' summary by J. T. Wilson, USA

4367. Caloi, P., Seismic wave velocities in the Earth's interior, particularly in the mantle (in Italian), *Atti Acad. Naz. Lincei, R.C. Cl. Sci. Fis. Mat. Nat.* **26,** 2, 130–136, Feb. 1959.

Caloi deduces new values for the seismic wave velocities in the mantle of the Earth by means of the Wiechert-Herglotz method, using the most recent seismic travel-time data available. Caloi's table shows a minimum velocity for longitudinal and transverse waves alike at a distance of 0.981076 r_0 (r_0 being the distance of the Mohorovičić Discontinuity) from the center of the Earth. The new velocity values are then applied to determine an analytical approximation formula in which r is expressed as a fraction of two polynomials in r/v (v being the wave velocity) of the second and sixth degree in numerator and denominator, respectively. Caloi uses this approximation to obtain an analytical expression for the relationship between travel time and epicentral distance. This, then, is applied in reverse to the determination of the focal depth of two earthquakes.

A. E. Scheidegger, Canada

4368. Helfenstein, H. G., Critical curves in seismic exploration, *Math. Mag.* **31,** 2, 85–91, Nov.–Dec. 1957.

The basic problem is to determine an underground surface of discontinuity, D, from seismic reflections. If the wave travel distance is known as a function of the position of the receiver, D may be determined as the envelope of a family of ellipsoids. The author shows that the envelope is undetermined and the method fails if the recording points are confined to certain straight lines or hyperbolas on the surface which pass through the shot point.

E. Pinney, USA

Courtesy Mathematical Reviews

4369. Puzyrev, N. N., The measurement of seismic velocities in boreholes (in Russian), *Trudi Vses. N.-i. In-ta Geofiz. Metodov Razvedki* no. 3, 80 pp., 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 9191.

Methods are described for measuring the velocities of propagation of elastic waves by means of a borehole seismograph. The

investigation embraces the evaluation of the vertical profiles of the hodographs of transient waves, methods of documentation of the data obtained by observation, construction of vertical hodographs, reduction of observed times to the vertical calculation of the velocities, and estimation of the accuracy of the results, as well as some modifications of the method of seismic core-sampling; the data of a seismic core-sample series in a number of boreholes are generalized. As a supplement, methods of calculation are exemplified. G. I. Pokrovskii

Courtesy Referativnyi Zhurnal, USSR

4370. Cartwright, D. E., On submarine sand-waves and tidal lee-waves, *Proc. Roy. Soc. Lond. (A)* **253,** 1273, 218–241, Nov. 1959.

Author investigates the stability of long waves, in the order of 500 meters, in a sand bed under a deep, low velocity and slowly varying water flow. Assuming a vertical variation in density and velocity, the only mechanism found permitting sand waves to grow is that of a stationary wave train in the lee of a fixed obstacle. The lee waves require a density gradient greater than a certain minimum. Because of varying conditions such as tides, storms and seasonal changes, it is difficult to establish the phase angle between the sand waves and the lee wave. Therefore for any particular wave number for the sand waves, the phase angle is assumed random and an rms amplitude spectrum is derived. For the rather special conditions to be found at the La Chapelle Bank at the mouth of the English Channel typical spectra are determined and good agreement in shape is obtained with observed spectra whether or not shear in the water column is considered. A growth rate of but several mm per year is predicted and is considered reasonable because of the very long sand wavelengths involved.

The rather special conditions associated with the proposed mechanism will probably restrict its consideration to only a limited number of areas, unless modifications to the boundary conditions, such as the bottom topography, are made.

H. G. Farmer, Jr., USA

4371. Neumann, G., and Pierson, W. J., Jr., A comparison of various theoretical wave spectra, *Inter. Shipbldg. Prog.* **6,** 53, 14–19, Jan. 1959.

This paper was read to the Symposium on the behavior of ships in a seaway, held at Wageningen in 1957, and represents the authors' opinions as of that date. By a theoretical wave spectrum the authors mean a mathematical formula fitted to measurements. Such formulas have been proposed by Darbyshire, Roll and Fischer, and Neumann, and are here compared with a set of new data obtained from wave pole and stereo-wave observations. For this set, the Neumann formula gives better agreement than the other two formulas.

In an addendum (January 1959), authors suggest that not too much significance should be attached to this result. They believe now that the several formulas may each have their own range of validity. Additional references to more recent work are given which indicate that considerable progress has been made since the paper was submitted. F. Ursell, England

4372. Klepikov, V. V., The derivation of the equation of balance of wave energy (in Russian), *Uch. Zap. Leningrad Vyssh. Inzh. Morsk. Uch-shche* no. 6, 19–22, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8834.

The equation of balance of wave

$$\frac{\partial}{\partial t}\frac{\gamma a^2}{2} + \frac{\partial}{\partial x}\frac{\gamma a^2 C}{4} - R_1 + R_2 = 0$$

where γ = specific gravity of water, R_1 intensity of wind-induced energy, R_2 intensity of frictional energy loss, $2a$ wave height, C wave propagation velocity along the $0x$ axis, obtained by V. M. Makkaveyev by solution of the hydrodynamic equations, is directly derived from the equation of equilibrium of a column of liquid, the kinetic and potential energy whereof are, by the theory of trochoidal waves, in sum equal to $1/2\ \gamma a^2$, while the inflow of energy to the column in question, from the adjacent layers of the liquid, is expressed by the same theory of trochoidal waves in the form $1/4\ \gamma a^2 C$. S. V. Zhak

Courtesy Referativnyi Zhurnal, USSR

4373. Soliak, E. M., Some problems on method in the evaluation of wave diagrams (in Russian), *Trudî Gos. Gidrol. In-ta* no. 66, 51–74, 1957; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8840.

Methods are described for measuring the height, length and period of waves. It is observed that the lack of standardization in the evaluation of wave diagrams impedes the obtaining of comparable results. It is suggested to resolve the wave diagrams into sinusoids with different amplitudes and periods; this enables a harmonic analysis in the first approximation. For the purpose of standardizing methods of analysis it is proposed to isolate the principal wave system in the diagram and from that to determine the mean period and height of the wave, reliably within 60–70%. These latter values may be used as a design basis.

A. S. Ofitserov

Courtesy Referativnyi Zhurnal, USSR

4374. Stockmann, V. B., The theoretical determination of the meridional boundaries of zonal circulation in the northern part of the Pacific Ocean (in Russian), *Meteorol. i Gidrologiya* no. 5, 19–24, 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8844.

It is pointed out that, in constructing a theory of equatorial counter-currents, the author obtained an approximate criterion for determining the boundaries of an equatorial counter-current from the known value of the zonal component of the tangential wind friction. The reliability of this criterion has been established by comparison with experimental data. It has been found that this criterion enables the determination not only of the boundaries of the equatorial counter-current but also of the interface between the trade winds and the westerlies. The results are presented of the determination of the boundaries of zonal circulation for the Northern half of the Pacific Ocean. The positions of the lines of divergence have also been determined. In the latter case, there is only qualitative agreement between the theoretical conclusions and the observed data. A. S. Sarkisyan

Courtesy Referativnyi Zhurnal, USSR

4375. Ivanov-Franzkevich, G. N., The problem of the vertical stability of aqueous strata (in Russian), *Trudî In-ta Okeanol. Akad. Nauk SSSR* **19,** 3–45, 1956; *Ref. Zh. Mekh.* no. 8, 1958, Rev. 8845.

The methods of evaluation of the vertical stability of aqueous strata in the oceans are analyzed. The physical significance of the presently-used criteria of static stability is elucidated, and a more suitable method for their calculation is indicated. In the author's opinion, in a stratified current of sea water, the Richardson number is the most suitable criterion of the appearance of turbulence. Existing evaluation of the critical value of the Richardson numbers is analyzed. D. L. Laikhtman

Courtesy Referativnyi Zhurnal, USSR

4376. Blanchard, D. C., Electrically charged drops from bubbles in sea water and their meteorological significance, *J. Meteorol.* **15,** 4, 383–396, Aug. 1958.

Electric charge and radius of drops ejected from a bursting bubble at an air-sea interface were determined by a modification of Millikan's oil-drop experiment. Instrumentation is illustrated and described. Both the natural and the induced charge were measured and photos of collapsing bubbles are shown. Drops of 3 to 20-micron radius carry natural charges of 2×10^3 to 5×10^3 elementary units, respectively. Induced charges reach 10^6 elementary units on drops of 50-micron radius. On drops smaller than 4-micron radius

the natural charge is positive; for larger drops the sign and magnitude of the charge seem to depend on the depth of water through which the bubble rises.

Rain, snow, and whitecaps can produce a great number of small bubbles in the surface waters of the oceans, carrying mostly positive charges that contribute to the space charge of the atmosphere. For positive induction fields of less than about 25 v cm^{-1} a positive charge is found on the small drops; for fields greater than 25 v cm^{-1} the induced negative charge exceeds the natural positive charge, resulting in a net negative charge. Calculations based on measurements of the bubble spectrum produced by white caps indicate that the charge on the drops may provide a countercurrent of the same order of magnitude as the fair-weather conduction current. The sea may be a source as well as a sink for the charge that maintains the earth's positive electric field.

Bibliography of 45 titles covers period from 1915 to 1957.

K. J. DeJuhasz, USA

4377. Schaefer, V. J., and Dieterich, J. H., The seeding of cumulus clouds by ground-based silver iodide generators (in English), *ZAMP* **10**, 2, 174–188, Mar. 1959.

Authors report on a cloud-seeding experiment carried out during the summer of 1957 in western Montana. Purpose was to determine whether seeding is effective for freezing supercooled water with view to preventing accumulation of large masses of liquid water in clouds at very low temperatures. Presence of such liquid water is thought to be related to electric charge separation and lightning occurrence. Hence frequency of lightning strikes and lightning-caused forest fires may be reduced by successful operation.

Experiment was undertaken because natural freezing nuclei active at temperatures above −20C are found to be rare, often absent in the area studied. Hence there is hope that the natural freezing process may be accelerated by introducing nuclei active at warmer temperatures, i. e. silver iodide. During the 1957 field experiment a "background" count of freezing nuclei was taken daily by airplane. Then, depending on the weather situation, seeding was carried out from a mountain ridge south of Missoula, Montana. Results were observed visually, by time lapse and still camera, by radar and by airplane.

Results are interpreted to have demonstrated that supercooled cumulus clouds can be converted to ice clouds by the operation, in that the clouds downstream from the seeding site showed the change of phase whereas elsewhere this did not occur on a number of days. This reviewer, who participated in some of the reconnaissance flights, can confirm this conclusion.

The 1957 experiment was not designed to indicate whether dry lightning discharges were reduced in frequency, but the results were taken as an encouragement for further experimentation.

H. Riehl, USA

4378. Heath-Smith, J. R., Atmospheric turbulence encountered by Viscount aircraft over Europe, Aero. Res. Counc. Lond. Curr. Pap. 463, 25 pp., 1960.

Counting accelerometer records were obtained from Viscount aircraft during 600,000 miles flying on European routes.

It is shown that the gust frequencies observed are in fair agreement with previous experience on more widespread routes.

The variation of turbulence below 10,000 ft during the year proved to be irregular and the maximum variation between monthly averages was about 3 to 1. At about 20,000 ft there was a single annual fluctuation with a maximum variation of the order of 25 to 1 and maximum intensity during the summer months.

From author's summary

Naval Architecture and Marine Engineering

(See Revs. 3926, 4008, 4043)

Friction, Lubrication and Wear

(See also Revs. 3848, 3971, 4036)

4379. Whitley, S., and Betts, C., Study of gas-lubricated, hydrodynamic, full journal bearings, *Brit. J. Appl. Phys.* **10**, 10, 455–463, Oct. 1959.

Authors describe tests on 2-in., 4-in., and 7-in. diameter gas bearings of plain cylindrical type with a narrow axial groove in the upper surface (unloaded half) extending over half the bearing length to improve the half-speed whirl characteristics. Speeds ranged from 3000 to 20,000 rpm. Gas lubricants were mainly hydrogen, nitrogen and neon selected to give a wide viscosity variation; argon and carbon dioxide were also used to determine the influence of the ratio of specific heats, i.e., whether isothermal or adiabatic conditions prevailed in the lubricant film. Length-to-diameter ratios ranged from 1 to 4.5. The effect of ambient pressure was also studied. Investigations dealt with the two important performance characteristics: (a) load capacity and (b) half-speed whirl.

(a) Load capacity: Film thickness measurements were made with capacitance-type probes. Results indicated that the conditions in the film were isothermal rather than adiabatic, which agrees with the findings of the majority of other investigators. Experimental load capacities were compared with the infinite isothermal bearing theories of Katto and Soda, Ausman, and a solution by the authors which carries the Ausman series expansion a term further. A discrepancy of about 24% exists between experiment and theory, half of which can be reconciled by connecting the infinite bearing theory by using the end leakage factors of Ausman; authors were unable to explain the remainder.

Tests on bearings without the axial groove were also run and the results compared with the grooved bearing. Grooving did not have any effect on the load capacity.

(b) Half-speed whirl: Authors give a brief theory of half-speed whirl and develop a criterion for cylindrical whirl and one for conical whirl which showed the influence of bearing inertia and length. The effects of parameters not covered by the theory, bearing clearance and load, are indicated graphically. The half-speed whirl results are not related to a complete analytical theory.

A. A. Raimondi, USA

4380. Kettleborough, C. F., Density variation effects in stepped-thrust bearings, *ASME Trans.* **81**E (*J. Appl. Mech.*), 3, 337–340, Sept. 1959.

Paper concerns the explanation of an anomaly, experimentally noted by the author (C. F. Kettleborough, "Further experiments on stepped-thrust bearings; the effect of step height". Proc. of the Institution of Mech. Engrs., International Lubrication Conference, London, Oct. 1959), occuring in the shape of the curves of the variation of the load and friction coefficients against the minimum thickness. Author puts forward the hypothesis that these anomalies are due to the effect of the density variation which may have an influence if the minimum film thickness decreases below a certain value. For this purpose the flow in the lubricant layer is calculated for a two-dimensional stepped bearing, assuming a linear variation of the density at each region.

Theoretical results confirm qualitatively the above-mentioned experiments.

V. N. Constantinescu, Roumania

4381. Matsuyama, T., and Kayaba, T., A study of the characteristics of bearing alloys, *Bull. JSME* **3**, 9, 1–6, Feb. 1960.

Some properties of friction and wear of Al-base bearing alloys under dry or wet condition were investigated. The results of this investigation were as follows: (1) Under dry condition: When the speed become high, the wear increased rapidly with the load beyond a certain amount. The wear decreased with the increase of speed to a certain minimum value and the speed at which the wear

was minimum became low as the load increased, and this tendency was conspicuous with AlJ1. (2) Under wet condition: The wear decreased generally with increases of load and speed. When AlJ1 was used, this decrease was greater. The coefficient of friction of AlJ1 increased rapidly with the decrease of Zn/P below a value of Zn/P where the coefficient of friction showed a minimum value. Under a certain load, the coefficient of friction was almost constant regardless of the speed with every alloy.

From authors' summary

4382. Horne, W. B., Experimental investigation of spin-up friction coefficients on concrete and nonskid carrier-deck surfaces, NASA TN D-214, 50 pp., Apr. 1960.

A series of landing-impact tests was conducted with a carrier-type jet airplane main landing gear to obtain data on spin-up friction coefficient for both concrete and nonskid deck surfaces for tire-inflation pressure of 260, 320, and 400 pounds per square inch. The sinking speeds investigated ranged between 12 and 19 over a forward speed range between 54 and 104 knots. Several impact and taxiing tests over a 1-3/8 in.-diameter arresting cable were also conducted. Results indicated somewhat lower spin-up friction coefficients for the nonskid deck than for the concrete surface.

From author's summary

4383. Bezborod'ko, M. D., Pavlovskaia, N. T., and Vinogradov, G. V., Friction machine for investigation of lubricating qualities of oil products *Indust. Lab.* **24,** 10, 1399–1401, Nov. 1959. (Translation of *Zavod. Lab., USSR* **24,** 10, 1267–1269, Oct. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

4384. Christian, J. B., Effect of metals on lubricants, Part 3, WADC TR 54-576 (PB 151 446; ASTIA AD 155 518), 23 pp., May 1958.

4385. Newman, A. D., Extreme pressure lubricants for marine gears, *Inter. Shipbldg. Prog.* **6,** 63, 486–492, Nov. 1959.

Letters to the Editor

4386. Re: AMR **12** (1959), Rev. 4444: **Solomon, L., Potential functions of displacement for Lame's dynamic equations** (in Roumanian), *Acad. Repub. Pop. Romine Comun.* **8,** 7, 647–655, 1958.

This paper is a continuation of an earlier paper [Displacement potential functions for the elastic equilibrium equation, *Acad. Repub. Pop. Romine, Buletin Stiintific, Sectia de Stiinte Matematice si Fizice*, **9,** 2, 415–431, 1957] in which the results were extended to the dynamic case.

The earlier paper was concerned with the representations of the displacement potential functions for Lame's static equations. By resolving the displacement vector into components which satisfy Poisson type equation, author now obtains the representations given by Papkovici, Korn, Trefftz and Boussinesq.

In order to clarify the above-mentioned review, the reviewer would like to point out that author's results were obtained independently of the similar solutions given by E. Sternberg and R. A. Eubanks.

M. Misicu, Roumania

4387. AMR **13** (1960), Rev. 79: **Bijlaard, P. P., Thermal stresses and deflections in rectangular sandwich plates,** *J. Aero/Space Sci.* **26,** 4, 210–218, Apr. 1959.

Reviewer states that Eq. [6] does not apply to sandwich plates. On the contrary, Eq. [39] was derived specifically for sandwich plates. However, Eq. [6] shows that in a homogeneous plate, simply supported at four sides, the transverse shear is zero. Recalling the principle of uniqueness of a solution in the linear theory of elasticity, the reasoning given in the paper runs like this:

Since the boundary conditions for a sandwich plate, simply supported at four edges (Eq. [7]), are also satisfied by the simply supported homogeneous plate, and for the homogeneous plate from Eq. [6] the transverse shears are zero, this same solution will also apply for the sandwich plate. For, with vanishing transverse shears, the shear deformation of the core is irrelevant, and the solution for the simply supported homogeneous plate will satisfy all equilibrium and compatibility conditions for the simply supported sandwich plate, so that it is *the* solution.

Using the sandwich plate Eqs. [36], [39], [46], and [47] for the simply supported case leads to the same result as the foregoing reasoning, since B_m and E_m appear to be zero, which makes the transverse shears zero.

The reviewer states that for the simply supported sandwich plate the transverse shears are not necessarily zero. The case is completely defined, so that, since the solution is unique, they are either zero or not zero. As shown here, and also in the paper, they are zero.

P. P. Bijlaard, USA

4388. Re: AMR **13** (1960), Rev. 741: **Foppl, L., and Monch, E., Practical photoelasticity** [Praktische Spannungsoptik], 2nd ed., Berlin, Springer-Verlag, 1959, xi + 209 pp. DM 30.

In the process of preparation of this review, certain errors were made in the 3rd and 4th paragraphs. The correct version of these two paragraphs is given below.

"The second edition is therefore completely revised, taking account of the principal advances of the past ten years, especially those concerning the three-dimensional photoelasticity. Let us also point out that the book contains certain interesting considerations on photoplasticity.

We recommend this second edition very much, not only to scientists who work in this field but also to any engineer who has to do with the delicate problem of the determination of a state of stress. By the way the book represents an evident pedagogical purpose, last but not least because of its illustrative pictures. Thus students of technical branches may also read it with interest."

H. Favre, Switzerland

The editors regret this error.

Books Received for Review

ABBOTT, I. H., and VON DOENHOFF, A. E., Theory of wing sections including a summary of airfoil data, New York, Dover Publications, Inc., 1959, x + 693 pp. $2.95. (Paperbound)

ATKIN, R. H., Classical dynamics, New York, John Wiley & Sons, Inc., 1959, ix + 273 pp. $5.25.

BEER, A., Vistas in astronomy, Vol. 3, New York, Pergamon Press, Inc., 1960, vii + 345 pp. $18.50.

BRAGG, W., The universe of light, New York, Dover Publications, Inc., 1959, x + 283 pp. $1.85. (Paperbound)

CARPENTER, S. T., Structural mechanics, New York, John Wiley & Sons, Inc., 1960, xi + 538 pp. $9.50.

CHANDRASEKHAR, S., Radiative transfer, New York, Dover Publications, Inc., xiv + 393 pp. $2.25. (Paperbound)

DRYDEN, H. L., and VON KARMAN, TH., Advances in applied mechanics, Vol. 6, New York, Academic Press, Inc., 1960, x + 294 pp. $9.

FERRARO, A., Piccolo dizionario metrologia generale, Bologna, Nicola Zanichelli Editore, 1959, x + 292 pp. 3.500 Lire.

GRAY, A., A treatise on gyrostatics and rotational motion, theory and applications, New York, Dover Publications, Inc., 1959, xx + 530 pp. $2.75. (Paperbound)

HENRY, F., and POURET, H., Rectification superfinition, Paris, Eyrolles, 1960, 146 pp.

HIGDON, A., OHLSEN, E. H., and STILES, W. B., Mechanics of materials, New York, John Wiley & Sons, Inc., 1960, xiv + 502 pp. $7.75.

JACKSON, A. S., Analog computation, New York, McGraw-Hill Book Co., Inc., 1960, ix + 652 pp. $13.50.

JACOB, C., Introduction mathematique a la mechanique des fluides, Bucuresti, Academiei Republicii Populare Romine, 1959, 1286 pp. Lei 66.50.

JONES, J. B., and HAWKINS, G. A., Engineering thermodynamics, New York, John Wiley & Sons, Inc., 1960, xviii + 724 pp. $8.50.

KAMKE, E., Differentialgleichungen, Losungsmethoden und Losungen, Part 1: Gewohnliche Differential-gleichungen, 6th ed., Leipzig, Geest & Portig K.-G., 1959, xxvi + 666 pp. DM 36.80.

KAMKE, E., Differentialgleichungen, Losungsmethoden und Losungen, Part 2: Partielle Differential-gleichungen erster Ordnung fur eine gesuchte Funktion, 4th ed., Leipzig, Geest & Portig K.-G., 1959, xii + 243 pp. DM 16.

KAYE, J., and WELSH, J. A., editors, Direct conversion of heat to electricity, New York, John Wiley & Sons, Inc., 1960, ix + 353 pp. + index. $8.75.

MASON, D. M., REYNOLDS, W. C., and VINCENTI, W. G., editors, Proceedings of the 1960 Heat Transfer and Fluid Mechanics Institute, Stanford University, June 15, 16, 17, 1960; Stanford, Calif., Stanford University Press, 1960, x + 259 pp. $8.75.

OBERT, E. F., Concepts of thermodynamics, New York, McGraw-Hill Book Co., Inc., 1960, xxi + 528 pp. $11.

PASLER, M., Mechanik Deformierbarer Korper, Band 1189/1189a, Berlin, Walter de Gruyter & Co., 1960, 199 pp. (Paperbound)

RALSTON, A., and WILF, H. S., edited by, Mathematical methods for digital computers, New York, John Wiley & Sons, Inc., 1960, xi + 293 pp. $9.

ROSEN, E., (translated and with notes by), Three Copernican treatises; the Commentariolus of Copernicus; the letter against Werner; the narratio prima of Rheticus, 2nd revised ed., New York, Dover Publications, Inc., 1959, x + 283 pp. $1.75. (Paperbound)

SCHAFFERNAK, F., Hydrographie, Graz, Akademische Druck- und Verlagsanstalt, 1960, ix + 438 pp. S. 230.

SNEDDON, I. N., and HILL, R., editors, Progress in solid mechanics, Vol. 1, New York, Interscience Publishers, Inc., 1960, xii + 448 pp. $15.50.

Symposium on particle size measurement (61st Annual Meeting of American Society for Testing Materials, Boston, Mass., June 26–27, 1958), STP no. 234, Philadelphia, Pa., American Society for Testing Materials, 1960, v + 303 pp. $6.25.

SZESZTAY, K., River forecasting on the Hungarian Danube, Budapest, Hungarian Research Institute for Water Resources, no. 6 (summary in English), 1959, 102 pp. + 26 charts.

VON MISES, R., Theory of flight, New York, Dover Publications, Inc., 1959, xvi + 629 pp. $2.85. (Paperbound)

WINTTERLIN, K., Kolbenverdichter, Grundlagen Innere Vorgange, Berechnung Ausfuhrung, Betrieb, 3rd revised ed., Berlin, Springer-Verlag, 1960, vii + 148 pp. DM 23.40

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Development of a Smooth Running, Double-Spool, Gas-Turbine Rotor System.
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Theoretical Stresses Near a Circular Opening in a Flat Plate, Reinforced With a Cylindrical Outlet.
Effect of Steam-Turbine Reheat on Speed-Governor Performance.
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Gas Turbine Progress Report Covering: Materials. Turbine Cooling. Fuels. Cycle Components. Compound Piston-and-Turbine Engines. Aviation. Rocket Turbines. Automotive. Railroad. Marine. Industrial and Central Station. Nuclear.
The Aerodynamic Approach to Furnace Design.
Use of Flow Models for Boiler-Furnace Design.
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Basic Principles of Combustion-Model Research.
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Power Test Code Thermometer Wells.
Flow-Induced Noise in Heat Exchangers.
The Effect of Fuel Types and Admission Method Upon Combustion Efficiency.
Torsion of a Prismatical Bar Whose Section Is a Crescent.
The Transient Response of Gas-Turbine-Plant Heat Exchangers—Regenerators, Intercoolers, Precoolers, and Ducting.
Stresses in Hollow Cylinders Due to Asymmetrical Heat Generation.
Dynamic Loading of Spur Gear Teeth.
Analytical Design of an Ackermann Steering Linkage.
Structural Error Analysis in Plane Kinematic Synthesis.
The Design of Linkages to Generate Functions of Two Variables.
Helical Springs of Hollow Circular Cross Section.
Design of Helical Springs for Minimum Weight, Volume, and Length.
Stress and Strain in Spinning Paraboloid Dishes.
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A Three-Dimensional, Tool-Life Equation—Machining Economics.
Observations on the Shearing Process in Metal Cutting and on the Angle Relationships in Metal Cutting.
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Labyrinth-Seal Leakage Analysis.
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Modulation Phenomena in Stall Propagation.
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Applications of Computer and Model Studies to Problems Involving Hydraulic Transients.
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Experience in the Use of the Gibson Method of Water Measurement for Efficiency Tests of Hydraulic Turbines.
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Transient Heat Transfer for Laminar Forced Convection in the Thermal Entrance Region of Flat Ducts.
Generalized Correlation of Boiling Heat Transfer.
Heat Transfer to a Boiling Liquid—Mechanism and Correlations.
Transient Heat Conduction in Elliptical Plates and Cylinders.
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Free Convection, Forced Convection, and Acoustic Vibrations in a Constant Temperature Vertical Tube.
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Heat Transfer From a Rotating Disk to Fluids of Any Prandtl Number.
An Approximate Treatment of Unsteady Heat Conduction in Semi-Infinite Solids With Variable.
Thermal Properties.

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Section 3—APPLIED MECHANICS. Presentation and publication of the fundamental analytical and experimental studies in this section were sponsored by the Applied Mechanics Division.

Experimental Surface-Wave Method for Recording Force-Time Curves.
Forced Torsional Vibration of Systems With Distributed Mass and Damping.
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Viscous Damping in Flexural Vibrations of Bars.
Natural Modes and Their Stability in Two-Degree-of-Freedom Systems.
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Instability and Folding Deformation of a Viscoelastic Medium in Compression.
Stress Distribution in Semi-Infinite Strip Subjected to Concentrated Load.
Postbuckling Behavior of Rectangular Plates With Small Initial Curvature.
New Theory of Elastic Sandwich Plates—One-Dimensional Case.
On Invariant Perforation in an Infinite Strip.
Thermal Stresses in Moderately Thick Elastic Plates.
Analysis of Plane Stress in Polar Co-ordinates.
The Stress Function of a Radial Strain.
Determination of Safe Loads of Beams Subjected to Twisting and Bending Moments.
Effect of a Nonisothermal Free Stream on Boundary-Layer Heat Transfer.
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Normal Vibrations of Uniform Plate Carrying Any Number of Finite Masses.
Transients in Simple Undamped Oscillators Under Inertial Disturbances.
On Laterally Loaded Semicircular Plate With Clamped Edges.
Direct Determination of Stresses in Plane Elasticity Problems.
Stresses in a Stretched Slab Having a Spherical Cavity.
Influence Coefficients for Edge-Loaded Short, Thin, Conical Frustrums.
Upper and Lower Bounds for Special Eigenvalues.
Analysis of a Compression Test of a Model of a Granular Medium.
A Reassessment of Deformation Theories of Plasticity.
Collapse Loads of Rings and Flanges Under Uniform Twisting Moment.
Creep of Thick-Walled Tubes Under Internal Pressure.
Strain-Hardening Solutions to Plate Problems.
Determination of Creep Deflection of a Rivet in Double Shear.
Boundary-Layer Solution for a Flow in a Diverging Passage Having a Swirl Component
Slow Rotatory Motion of a Circular Disk About One of Its Diameters in a Viscous Fluid.
Thermal Stresses Owing to a Hot Spot in a Rectangular Strip.
Impact and Moving Loads on a Slightly Curved Elastic Half Space.
Stability of Forced Oscillations With Nonlinear Second-Order Terms.
On Inertia Effects in a Transient Thermoelastic Problem.
Coupled Torsional and Longitudinal Vibrations of a Thin Bar.
Production of Rotation in a Confined Liquid Through Translational Motion of the Boundaries.
Nonlinear Creep Deformations of Columns of Rectangular Cross Section.
Forced Vibrations of a Circular Plate.
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Carrying Capacity of Elastic-Plastic Shells With Various End Conditions.
Extensional Vibrations of Elastic Plates.
Triaxial Tension at the Head of a Rapidly Running Crack in a Plate.
Viscous Flow Through Tubes of Multiple Connected Cross Sections.
On the Accuracy of Some Shell Solutions.
The Drag on Spheres and Cylinders in a Stream of Dust-Laden Air.
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Incremental Stress-Strain Law Applied to Work-Hardening Plastic Materials.
On the Plastic Flow of Coulomb Solids Beyond Original Failure.
The Free Vibrations of Grillages.
Piping Flexibility Analysis by Stiffness Matrix.
A Photoelastic Approach to Transient Stress Problems Employing Low-Modulus Materials.
Rupture Characteristics of Safety Diaphragms.
Bending of Isosceles Right Triangular Plates.
Developments in the Application of the Grid Method to Dynamic Problems.
The Solution of Elastic Stability Problems With the Electric Analog Computer.
Symmetric Vortex Separation on Circular Cylinders and Cones.
Thermoelastic Problem for a Transversely Isotropic Hollow Sphere Embedded in an Elastic Medium.
Transient Analysis of Stress-Wave Penetration in Plates.
Transverse Flexure of a Semi-Infinite Thin Plate Containing an Infinite Row of Circular Holes.
Fundamental Frequency of a Thin, Flat Circular Plate Simply Supported Along a Circle of Arbitrary Radius.

DESIGN DATA AND METHODS

Stress-Concentration Factors for T-Heads.
The Frequency of Vibration of Rectangular Isotropic Plates.
Factors of Stress Concentration Due to Elliptical Fillets.

BRIEF NOTES

Buoyancy Effects in Forced-Convention Flow. Thermally Induced Twists in Thin Plates. Deflections and Vibrations of Clamped Sectorial Plates. Thermal Distributions Without Thermal Stresses. Thin-Walled Cylinders Under Torsion and Pressure. Transient Heat Transfer for Flow in Ducts. Upper and Lower Bounds for Stiffness of Plates. Cross-Section Distortion and the Timoshenko Beam Equation. Analysis of Paraboloidal Shells. Natural Frequencies of Two Nonlinear Systems. Response of a Slab to Impact. Thermal Stresses in Long Cylindrical Shells. Dynamic Characteristics of Undamped Vibration Systems. Large Deflections of a Clamped Elliptical Plate. Thermal Stresses at Spherical Cavities. Deflection of a Thick Ring in Diametral Compression. The Biot-Willis Coefficients for a Sandstone. Circular Plates on Elastic Foundation. Frequencies of Vibration of Stiffened Plates. Design of a π Network for Heat-Flow Analog. Stress Distribution in a Square Tube. Creep of Elastic Belt on a Pulley. Modification of Rayleigh's Principle for Calculating Beam Frequencies. Yield Point Load of an Annular Plate. Analysis of Indeterminate Structures by Displacement Method. Internal Damping of Thermal Origin in Thin Wires. Lateral Buckling of Tapered Narrow Beam. Stresses in Infinite Wedges Tapered in Width and Thickness. Minimization of Spring Torque. Steady-State Response of Linear Vibration Systems. Further Understanding of Shakedown Theorems. Series Solution for Ellipsoidal Shells.

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